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A STUDY OF AIR FORCE FLIGHT SIMULATOR PROGRAMS

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AEROSPACE MEDICAL RESEARCH LABORATORIES

JUNE 1967

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FOREWORD

This study was initiated by the Behavioral Sciences Laboratory of the Aerospace Medical Research Laboratories, Aerospace Medical Division, Wright-Patterson Air Force Base, Ohio. The work was performed by the Behavioral Sciences Laboratory and BioTechnology, Inc., of Arlington, Virginia, under contract AF 33(615)-2968. The research herein was performed between September 1966 and April 1967. Dr. Alfred F. Smode served as principal investigator for BioTechnology, Inc., from the inception of the project through November 1966. Mr. Eugene R. Hall directed the project to its completion.

The work was performed in support of Project 1710, "Human Factors in the Design of Training Systems," and Task 171003, "Human Factors in the Design of Systems for Operator Training and Evaluation." Dr. Gordon A Eckstrand, Chief of the Training Research Division, was the Project Scientist.

Special recognition is due to Lt. Col. Benjamin Fithian, Headquarters USAF (AFXOPXY-2) for arranging and coordinating visits to Air Force operational training units and to Col. Howard A. Jones, Special Training Devices Division, Directorate of Personnel Training and Education.

Appreciation is extended to Dr. Alfred F. Smode for his assistance in initial formulations of the objectives of the survey and for collecting portions of the survey data.

This technical report has been reviewed and is approved.

WALTER F. GRETHER, Ph.D.
Technical Director
Behavioral Sciences Laboratory
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ABSTRACT

This report describes flight simulator utilization and training practices within the U.S. Air Force. Data are presented concerning simulator training objectives, curricula, instructional methods, personnel, and support factors which affect utilization and program effectiveness. Information relating to the acceptance of flight simulators by pilot training personnel is included. In addition, recommendations and research issues are presented for improving the effective utilization of existing flight simulators and for the development of future simulator training requirements and programs.

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SECTION I

INTRODUCTION

Although flight simulators have been used for many years, there is no organized body of information that defines current training practices with these devices. There are several reasons for this. Research concerning effective utilization of simulators has been more sporadic than systematic. Consequently, simulator use during training has been based on such factors as availability and "expert opinion" rather than on firm data gained through controlled experiments. Another element affecting simulator utilization is the level of pilot acceptance. Simulators draw mixed emotions from pilots. Many regard simulators as a threat to flying time, with implications both for mission effectiveness and for flying safety. This concern encompasses the full array of flight missions, with the most criticism, however, coming from those who rely most heavily upon outside-the-cockpit visual cues and kinesthetic feedback from inflight acceleration forces for mission performance. These criticisms are understandable. Visual and motion parameters are difficult to simulate with fidelity. There are no fully satisfactory simulators for this purpose in the Air Force today. Technological progress in the flight simulation state of the art, however, is being made rapidly.

The increasing complexities and operating costs of the new generation of aircraft, coupled with rising demands for pilots, are placing severe requirements on the Air Force training establishment. For this reason, many Air Force officers believe that increased simulator training will be required in the future. This appears to be an area in which considerable gains could be realized in improving flight training. Solutions must be found for the many unanswered questions on a more reliable basis than expert opinion. Empirical data must be available to preempt edicts directing an overuse of simulators. In short, maximum efficiency in using these devices will depend on information provided through an increased emphasis upon controlled research. Careful attention to the elements and components of simulator training programs and to the use of flight simulators in the instructional process should improve the product of pilot training programs.

At present, there is no single source of information that can readily be used as a basis for determining where the requirements for improvement exist. The need for collecting and organizing the widely scattered data reflecting current Air Force flight simulator programs and for determining in some measure the effectiveness of these programs served as the impetus for this study.

BACKGROUND

U. S. Air Force commands concerned with training pilots have used flight simulators for almost two decades. This use is based on the belief that the simulator provides a useful environment for the learning of certain aspects of the flying job. A recent review of research findings relevant to pilot training (Smode, Hall, & Meyer, 1966) indicates that while this belief is undoubtedly valid, very little precise information is available concerning the value of these devices to the pilot training process.

Previous research which has compared the subsequent flying performance of groups given portions of their training in simulators versus nonsimulator-trained groups has demonstrated, qualitatively, the utility of these devices for pilot training. Certain of the skills required to fly an aircraft can be acquired on the ground in the simulator. Thus, flying time can be reduced by the judicious use of simulators without apparent sacrifice to the quality of the end product. In all instances, however, it appears that beneficial effects are greater for procedural items than for items involving dynamic control of the aircraft.

Limits on the amount of transfer obtainable from the flight simulator traditionally have been ascribed to limits in the degree to which simulator tasks represent corresponding aircraft tasks. Many have concluded that increased fidelity of simulation would lead to higher levels of transfer to aircraft operations. However, as the review cited above also noted, the ultimate value of the simulator depends on more than just fidelity of simulation. The way in which it is used in the pilot training process is quite important. In many cases, instructional quality may substitute for less than optimal fidelity of simulation. The value of a simulator of given fidelity may be extended by attention to other aspects of the training system of which the simulator is a part. However, the conditions of present-day flight simulator utilization by the Air Force are largely unknown and require identification and assessment before improvements in use can be effected.

PURPOSE OF THE STUDY

The purpose of the present study is to examine Air Force flight simulator programs and to provide information needed to improve the utilization of existing flight simulators and to develop future simulator training requirements and programs. Specifically, this study investigates the use of simulators for pilot training and attempts to determine:

(a) the current status of synthetic flight training programs; (b) the objectives of these programs; and (c) constraints within the programs resulting from administrative considerations, equipment availability, maintenance, and the instructional system.

Items examined during this study include administration of simulator training programs, development and content of curricula, instructional methods, selection and preparation of simulator instructors, and other factors which affect utilization and program effectiveness. The study also provides data concerning the extent to which those involved in pilot training accept (i.e., believe in the value of) flight simulators for pilot training. A final contribution is the identification of research issues for improving future simulation facilities.

CONDUCT OF THE STUDY

The purpose of the study required that a large amount of data be obtained from Air Force units. Information was needed to describe the way in which flight simulators are being used in the training process and to describe policies and practices underlying this use. Three sources of data were identified as relevant. These were:

1. Air Force and major command manuals, regulations, directives, and other documentation pertinent to the establishment and conduct of a simulator training program.

2. Interview data obtained from individuals using flight simulators at operational training units.

3. Records pertaining to the amount and extent of utilization of flight simulators for pilot training purposes.

To achieve the goals of the study, visits were made to a number of Air Force units at various organizational levels. The plan called for visits to installations within each of five major commands: Tactical Air Command, Military Airlift Command, Strategic Air Command, Air Defense Command, and the Air Training Command. Visits began at Headquarters Air Force level, proceeded to the command headquarters, from there to the Combat Crew Training School (CCTS) or its equivalent, and finally to individual units employing simulators in pilot training. An itinerary of the visits made is shown in the Appendix.

At each of the units visited, information and written documentation in each of the above categories was obtained. To guide the data collection

effort, a questionnaire/checklist form was devised. Its purpose was to insure that all key points were covered during a field visit. It was not intended that individual items be administered in any standardized way. Questionnaire items were arbitrarily divided into four areas dealing with administration of simulator programs, technical and training system features of these programs, pilot acceptance of the devices for training, and a set of open-ended questions designed to elicit additional information about simulator training.

At the field units, the major effort was devoted to interviewing Instructor Pilots (IPs). Other individuals, involved directly or indirectly in pilot training (e.g., unit commanders, standardization/evaluation personnel, maintenance supervisors, training officers, etc.) were also interviewed. Although certain specific questions were asked, the greatest wealth of information was obtained from the open-ended items. These questions, asked of all Instructor Pilots, were:

What are you trying to accomplish with the simulator?

What are the most useful features of the simulator for your training needs? What is taught well? What is not trainable in the simulator?

What administrative events work against the effective utilization of the simulator?

What is the most serious difficulty in training pilots (for their mission) in the simulator (most serious deficiencies)?

What needs to be changed (corrected) in the simulator program to achieve training goals or to increase trainer effectiveness (in design or in use)?

Much information was obtained in the interview sessions, and many kinds of written documentation were provided by all organizational levels. These written materials include Air Force and Command regulations, directives, local unit operating instructions, course syllabi, simulator lesson plans, instructor guides, student study guides, proficiency records, simulator critiques, training standards, and other items pertaining to the use of simulators. Information from these two primary sources served as the basis of this report. A number of official Air Force photographs depicting flight simulation equipment were also obtained, and several of these have been used in this report. Although a large number of monthly trainer utilization reports (see pp. 24-28) were obtained at Command- and unit-level organizations,

subsequent work with these records and attempts to analyze and evaluate the data recorded on them were unrewarding. Hence, they have not been used in any appreciable way.

Flight Simulators Surveyed

Table I lists the flight simulators included in this study. Column 1 of this table lists the official Air Force designation for these devices (see AFM 65-110, Attachment 15). Column 2 lists the aircraft simulated by the device. The final column notes the base at which the training program employing the device was discussed.

The flight simulators included in this study were chosen to represent a variety of aircraft types in current operational use in the Air Force. Devices simulating the flying characteristics of single-place, dual-place, and multiplace aircraft having diverse missions and capabilities were included. Also included were the trainers (T-4, T-7, and T-26A) used by the Air Training Command in the Undergraduate Pilot Training Program. Although the Air Force classifies trainers for the T-37 and T-38 aircraft as instrument trainers rather than as flight simulators (AFM 65-110, 1965), they were included because of their importance in initial pilot training and also because they represent the pilot's first formal exposure to synthetic flight training equipment which provides practice on substantial segments of the overall flying task. Consequently, experience with these devices can be expected to strongly influence pilots' attitudes and expectations of value toward the flight simulators they will encounter in subsequent flying training programs.

In all, ten basic types of aircraft are represented by the simulators and two by the instrument trainers included in the study. Different models and versions of a basic aircraft, designed to fit different needs of a Command, are also included. The flight simulators for the C-141 and C-130 aircraft and for versions of the F-4 aircraft (F-4C, F-4D, RF-4C) have cockpit motion systems which provide simulated pitch and bank movement, and were included on this basis. Although a deliberate attempt was made to include in this study simulators having external visual attachments, it was discovered that these "visual simulators" were inoperative at all of the bases visited. Hence, no assessment of training value and pilot acceptance based on experience with these devices could be made.

ORGANIZATION

The remainder of this report is organized into two major sections. Section II describes current Air Force flight simulator training programs.

TABLE I

FLIGHT SIMULATORS INCLUDED IN THE STUDY

Type Designation	Aircraft Type	Location
ATC		
A/F 37A-T4	T-37	Williams AFB
A/F 37A-T4	T-37	Randolph AFB
A/F 37A-T7	T-38	Williams AFB
A/F 37A-T7	T-38	Randolph AFB
A/F 37A-T26	T-38A	Williams AFB
TAC		
AF/F 37A-T19	C-130E	Sewart AFB
MB-12	C-130A	Sewart AFB
MB-35	RF-101A	Shaw AFB
MB-9A	RB-66B	Shaw AFB
A/F 37U-T2	RF-4C	Shaw AFB
A/F 37U-T1	F-4C	Davis-Monthan AFB
A/F 37U-T1	F-4C	George AFB
A/F 37U-T3	F-4D	Davis-Monthan AFB
A/F 37U-T3	F-4D	George AFB
SAC		
MB-26	KC-135A	Castle AFB
MB-26 (Mobile)	KC-135A	Castle AFB
MB-41	B-52D	Castle AFB
MB-41 (Mobile)	B-52D	Castle AFB
MB-41A	B-52F	Castle AFB
MB-41A (Mobile)	B-52F	Castle AFB
AF/F 37A-T1	B-52G	Castle AFB
AF/F 37A-T1 (Mobile)	B-52G	Castle AFB
AF/F 37A-T25	B-52H	Castle AFB
MAC		
MB-10	C-124C	Dover AFB
MB-10	C-124C	Tinker AFB
MB-16	C-133A	Dover AFB
A/F 37A-T24 (Curtis-Wright)	C-141A	Tinker AFB
A/F 37A-T24A (Link)	C-141A	Tinker AFB
A/F 37A-T24A	C-141A	Dover AFB
ADC		
MB-40	F-101B	Tyndall AFB
MB-42	F-106A	Tyndall AFB

The material presented is responsive to two general questions: "What does the Air Force attempt to accomplish through the use of flight simulators?" and "What is the process established for achieving these goals?" Section II is purely descriptive.

Section II discusses and evaluates the components of simulator instructional systems. This discussion is based principally on comments of Air Force training and support personnel concerning particular aspects of simulator training programs. The discussion identifies strong and weak areas in simulator training programs. It also identifies those areas in which research effort might profitably be directed toward improving future simulator programs and offers recommendations, where appropriate, for improving existing programs.

A final section, Section IV, provides a brief summarization of the highlights of Sections II and III.

SECTION II

DESCRIPTION OF FLIGHT SIMULATOR TRAINING PROGRAMS

In this section, representative Air Force flight simulator training programs are described. Various components of these programs are treated successively. These are the objectives established for simulator training, the content and conduct of simulator training, and proficiency assessment practices. Support practices which may affect the utilization and training effectiveness of these devices are also described. A major consideration for simulator training effectiveness is the instructor who conducts simulator training. Thus, considerable text is devoted to describing his preparation for this job and to the techniques employed for controlling instructor quality. The final portions provide data on costs associated with simulator training and describe the Strategic Air Command mobile simulator program.

OBJECTIVES OF SIMULATOR TRAINING

Information relating to the objectives of simulator training was culled from a variety of documents and was also obtained through direct questioning of training personnel. It is clear from both sources that the principal objectives concern the development of proficiency in the procedural components of flying tasks.

Documentation of Objectives

Flight simulator training program objectives are described in a variety of sources. Most commonly, they are contained in Air Force and Command 51-series (Aircrew Training) manuals for the aircraft. They may also be found in Command training manuals (e.g., SAC Manuals 50-3, 51-2, 50-8, 50-24) or regulations (e.g., SAC Regulation 50-46, MAC Regulation 50-3).

The Aircrew Training Manuals (e.g., ADCM 51-106, F-106 aircraft; ADCM 51-101, F-101 aircraft; AFM 51-101, RF-101 aircraft; AFM 51-34, F-4 aircraft; AFM 51-130, C-130 aircraft) contain simulator training objectives for transition, qualification, and continuation training of aircrew for specific aircraft. These manuals stipulate the length of simulator training and contain suggested lesson plans. While simulator training objectives are not explicitly set forth, it is clear from the suggested lesson plans that the intent is to impart proficiency in the

procedures required for operation of the aircraft. Emphasis is placed on emergency procedures. The excerpt below, taken from AFM 51-101 (p. 6), is representative of this class of manual. The student pilot is required to complete the following prior to initial checkout in the RF-101 aircraft:

> A minimum of 10 hours of instructor supervised training in an RF-101 flight simulator before initial flight. Simulator transition missions will be as follows:
>
> (1) Familiarization.
> (2) Familiarization and emergency procedures.
> (3) Single engine and emergency procedures.
> (4) Navigation, cruise control, and emergency procedures.
> (5) Pilot proficiency check.

SAC Manuals provide more explicit definitions of simulator training objectives. SACM 51-2, for example, outlines the flight simulator course for KC-135 aircrew transition training. The course is designed to supplement academic and flying training. The manual states (p. 38):

> The purpose of this training device is to simulate normal and emergency operating procedures for the pilot and copilot, and, by so doing, provide a means to improve proficiency and coordination in operating techniques. . . .
>
> The flight simulator will also be used, as much as possible without decreasing emergency procedures training, to accomplish instrument training. . . .

The objectives of the SAC continuation training program (SACM 50-24) are more succinctly stated. The objectives of simulator training in this case are to provide opportunity for each pilot (B-52, p. 82, and KC-135, p. 90) and copilot (KC-135) to practice each emergency at least once a year. Special emphasis is to be placed on landing and takeoff emergencies.

Command regulations, for example, MAC Regulation 50-8 and SAC Regulation 50-46, also establish objectives for simulator training. MAC Regulation 50-8 states that flight simulators will be used:

> 1. To provide initial training in normal and emergency procedures to aircrew transitioning to new and complex aircraft.

2. To increase aircrew proficiency in all normal and emergency procedures that can be reproduced realistically in the flight simulator. Particular emphasis will be placed on emergency procedures which can not be accomplished safely in the aircraft.

3. To minimize expenditure of aircraft flying hours necessary to qualify and upgrade aircrews.

It also requires that flight simulator courses be established for aircrews and that this training be "designed to provide instruction in normal and emergency procedures for inexperienced aircrew members and for personnel converting to new aircraft." A flight simulator course to provide annual evaluation and refresher training is also prescribed. The objectives of this course are to improve aircrew standardization and to provide "maximum training on inflight emergency procedures and maneuvers which, due to flying safety, cannot be accomplished during flight operations."

Training use of simulators within the Strategic Air Command is governed by SAC Regulation 50-46. This regulation provides that flight simulators will be used to:

a. Provide initial training in normal and emergency procedures to crews converting to new and complex aircraft.

b. Increase and maintain crew proficiency in accomplishing all emergency procedures in areas adequately simulated for this purpose. Special emphasis will be placed on emergencies that have contributed to actual aircraft accidents or incidents.

SAC Regulation 50-46 establishes the primary mission of the simulator as one of providing training in aircraft emergency procedures. It stipulates however, that the simulator may be scheduled "to accomplish the instrument training requirements contained in appropriate volumes of SAC Manuals 50-8[1] and 50-24" (Ground Training Requirements).

In the Air Training Command the objectives of synthetic trainer practice are presented in the Undergraduate Pilot Training Syllabus.

---

[1] SAC Manual 50-8 is divided into 9 volumes, each of which deals with training requirements for particular aircraft or concepts.

The syllabus requires trainer practice to develop proficiency on emergency procedures prior to flight in the training aircraft. Practice on instrument procedures is given throughout the course prior to the corresponding aircraft flights. This is intended to develop proficiency in the use and interpretation of flight instruments.

Interview Data

In addition to the information about training objectives available from published sources, other relevant data were obtained through interviews at the training units visited. All of the IPs interviewed, plus a number of other personnel having administrative and/or technical responsibility for training programs, were asked questions relating to the objectives of the simulator training program. The universal answer to these questions was that the principal objective was to teach flight procedures for normal and emergency conditions.

The emphasis of Air Force flight simulator programs is distinctly on the teaching of emergency procedures (both by regulation and by practice), but these are not the only items which are taught. In response to the question, "What are you trying to accomplish with the simulator?" the most frequently occurring responses were: to teach emergency, normal, and instrument procedures (in that order). Other more specific training objectives mentioned were:

Instrument scan and cross-check training.

Instrument interpretation.

Checklist accomplishment.

Cockpit familiarization including function and location of switches and components.

Crew coordination.

Tactical procedures such as weapon selection and preparation (for firing) and procedures in the techniques of air/air radar intercept.

Ejection procedures.

Systems knowledge.

Transition to unfamiliar instruments.

Standardization of operating procedures.

Instill confidence in trainee that he can handle the aircraft.

Provide degree of familiarization with aircraft performance characteristics before flight.

Communications procedures.

Limited degree of aircraft handling techniques, such as proper handling of yoke and throttles and power handling techniques.

The extent and depth of training given in the simulator on particular items is a matter for local determination. Air Force and Commands generally require only that training be given in certain broad areas (i.e., normal and emergency procedures). More specific training objectives are established by the individual training units based on local needs.

CONTENT OF SIMULATOR INSTRUCTION

The content of simulator training, in keeping with the established objectives, is heavily loaded with procedural items required for safe operation of the aircraft and/or its systems. Initially this content is specified in broad terms or in outline form in the same documents which contain the training objectives. Using these guidelines, local training groups develop the specific simulator syllabus and modify it as needed. This process is explained below.

Syllabus Guides

The Aircrew Training Manuals (51-series) require that simulator training be given and specify the length of the simulator course and/or specific lesson. Suggested mission outlines are also contained in these manuals as applicable to the phase of training that the pilot is in. For example, ADCM 51-101 (Volume I) contains simulator mission outlines for transition training (Phase I), qualification training (Phase II), and continuation training (Phase III). Examples of these mission outlines for each phase are shown in the Appendix for the F-101 aircraft (Figures 7, 8, & 9). A sample mission for qualification training in the F-4 aircraft (AFM 51-34) is shown in Figure 10.

The specific items contained in outlines in the Aircrew Training Manuals and in other manuals, documents, directives, regulations, etc.,

are usually considered as minimum items to be included in the simulator course of instruction. Other items usually are also included by the developers of the specific syllabus but within the timeframe established for synthetic training.

Syllabus Development

Using the general guidelines contained in the various documents referenced above, local training units prepare the specific syllabus that will be used to conduct the simulator portion of required training. Generally, these syllabi are prepared directly by the IPs responsible for conducting training. Expert knowledge gained from experience with the aircraft, or with similar aircraft, serves as the basis for this development. Coordinative inputs from local groups such as the standardization/evaluation function and (the) local training office(s) are also involved. The general procedure is for the local IPs to write the syllabus, coordinate it locally, and forward it through channels for higher level concurrence.

Initial syllabus development, and length of the course, are based on the material and outlines contained in the Aircrew Training Manuals and whatever other existing Air Force and Command regulations, directives, manuals, etc., are applicable to the course content. The desired end result of the training is, of course, also a guiding factor. If the intent of the overall course is only to transition the pilot into a new aircraft, the simulator syllabus will be structured to allow a maximum amount of training on the normal and emergency procedures involved in successful operation of the aircraft. The emergencies contained in the syllabus will include, as a minimum, those items identified in the Technical Orders ("dash-ones") for the aircraft as critical to its safe operation. These items are printed in boldface type in the dash-one manual. Other emergencies which may be included in the syllabus are those items which have occurred during experience with the aircraft or with similar aircraft in the operational environment.

If the overall training program is intended to qualify the pilot as operationally ready in the aircraft, portions of the simulator syllabus will be written to provide the student familiarization with, and practice on, his onboard systems. Generally, this will involve provision for practice on various items of sensor equipment and on the techniques and procedures involved in accomplishment of phases of the aircraft mission.

Once the syllabus has been developed, a period of time is required to refine and standardize it. Work with "experimental" classes and

assessment of the quality of those pilots trained under the syllabus begins immediately, with progressive changes being made to the syllabus unitl training personnel are satisfied with its content.

Syllabus Change

The number of hours allocated to simulator training is a relatively inflexible quantity. Changes are rarely made because of the effects on support functions they would entail. Changes to the content of training are, however, easily effected, and in actuality, the syllabus is in a nearly continuous state of change. A variety of factors may dictate the necessity for change.

Training requirements often change because of modifications to the aircraft resulting in changes in performance characteristics or from installation of new instruments (e.g., Flight Director System) or new equipment (e.g., terrain-avoidance radar). Changes to the aircraft mission or changes in the mission profile also may require a content change. A common occurrence is the changing of the syllabus to provide training on items which have been identified as causal factors in aircraft accidents/incidents. On the basis of work with a given syllabus, IPs may also decide that changes are needed to improve the quality of pilots completing the course. Less frequently, the course may be changed in response to student criticisms of the training provided. Also, a number of commands require that a periodic review of the content of flying training courses be made by training personnel and standardization/evaluation personnel to determine if changes to existing syllabi are required (e.g., SACR 50-46, MACR 50-8, TACR 60-2).

Changes to the syllabus may be initiated at any level within a command. Local training units may determine that a change is needed and revise the syllabus accordingly with notification to higher levels. Command headquarters may also request that a change be made to the current flying training program. In either case, the specific change is written by the local training unit and incorporated into the training program.

CONDUCT OF TRAINING

The way in which the simulator is used in the pilot training process is described herein. Two topics are discussed: the sequence of training, which considers the temporal relationship between simulator and aircraft practice periods, and instructional practices using the simulator.

Training Sequences

Placement of simulator training within the overall training program varies within the Air Force. In some cases, some of the required simulator training is given while the student is in the engineering ground school for the aircraft. Here, the simulator is used not only to prepare the student for flight but also to demonstrate failures and their consequences, and otherwise to augment his knowledge of systems operation. In other cases, all simulator training is given in a block after completion of the engineering phase of ground school and before flight in the aircraft. Other programs intersperse flying lessons and simulator lessons.

All of the flight simulator programs studied have the common characteristic that at least some degree of simulator training is given prior to the student's first flight in the aircraft. The amount given ranges from a low of 4 hours (F-4, RF-4C aircraft) to a high of 30 hours (C-130). Some programs do not require additional simulator training once the pilot has successfully transitioned into the aircraft. The other programs examined, however, do provide simulator training while the student is actually in the flying phase, but for different reasons. In the case of interceptor-type aircraft (e.g., F-4, F-106, F-101), additional simulator time is given during the qualification phase of training. These additional lessons are aimed at providing the trainee practice in tactical procedures and techniques of radar intercept. These lessons are usually given while he is completing transition flying lessons and before he begins flying practice intercepts in the aircraft. In the RF-4C program, simulator training is given during the flying phase to familarize the trainee with his onboard systems (e.g., cameras, sensor equipment, etc.).

The training programs for the B-52 and KC-135 aircraft also have simulator training during the flying phase but this is to teach emergency procedures for these aircraft. Although not the general practice within MAC units, at least one training program for MAC aircrew gives the trainee simulator training during the flying phase. These lessons are also directed at developing proficiency in emergency procedures prior to the time that the trainee will encounter them in the air. Table II below summarizes the simulator training given before and during aircraft training missions for various programs.

Air Training Command units provide some trainer time before flight, but the bulk of synthetic trainer use occurs while the student is in the flying phase. In the T-37 and T-38 programs, the student receives cockpit and emergency procedures training prior to flying the aircraft.

TABLE II

SEQUENCES OF SIMULATOR TRAINING

Aircraft	Average Length of Simulator Lesson (hours)	No. of Lessons before aircraft	No. of Lessons Interspersed with Flying Lessons and Total Time (hrs.)	
F-4	2	2	3	(10)
RF-4C	2	2	2	(8)
E/RB-66	3	5	0	(15)
RF-101	2	4	.5	(9)
C-130	3	10	0	(30)
F-106	1.5	6	5	(16.5)
F-101	1.5	6	4	(15)
B-52	3	5	4	(27)
KC-135	3	4	4	(24)
C-141	4	7	0	(28)
C-124	4	7	0	(28)
C-133	4	2	4	(24)

After flying begins, he receives instrument training on the synthetic trainers prior to corresponding aircraft lessons. The T-37 syllabus, "for better trainer utilization," allows students to progress "a maximum of six trainer lessons ahead of the aircraft lesson." The T-38 syllabus also allows progression as far as six lessons ahead of the aircraft lessons up to lesson T-10. After this lesson, however, "it is desired that the instrument trainer lessons be flown as close as possible to the desired syllabus flow."

Training Practices

Within the time and content framework established by the syllabus, the individual Air Force Instructor Pilot is allowed considerable freedom in satisfying established requirements and in training his students to the required degree of proficiency. Lesson plans developed locally are used by the IP to conduct simulator training sessions. These, however, are intended to be used principally as guides and are not rigid procedures which must be followed in training.

What to emphasize in training is left to the IP's discretion, based on his assessment of where an individual student is weak. In those cases where the simulator has a cockpit motion system, the decision to use this capability during training is usually made by the IP. Instructional style and, often, amount and kind of instruction given are varied to fit individual student needs. Timing and sequencing of malfunction presentation are also usually determined by the IP, because of his expert knowledge of realistic conditions for the development or occurrence of given types of emergencies.

A "no surprise" concept is followed in training. That is, the student generally knows well in advance of a given simulator lesson what will be covered in that lesson and is given ample time to prepare himself for it. Each simulator practice period is immediately preceded by a thorough briefing on the items to be covered in the simulator during that period. After the lesson, the student(s) is debriefed, and a review and critique are given by the IP. A sample of the KC-135 simulator student study guide is shown in the Appendix as Figure 11. Materials such as these are given the students at the beginning of training.

Support for simulator training sessions is usually provided by enlisted maintenance personnel assigned to the simulator section. They assist the IP by functioning as device and/or radio aids operators. They also simulate ground station voice communications and act as ground controllers (e.g., GCA, GCI). At two of the bases visited,

however, enlisted personnel are not used for this purpose. Based on the opinion that enlisted personnel are not technically qualified to "train" pilots in any way, IPs perform these functions themselves.

The normal training practice within MAC, TAC, and ADC is to match students with a particular IP. The same IP then stays with the student throughout the simulator and flying training phases. (In ADC, the IP also teaches aircraft engineering). Thus, the same instructor provides all simulator training and all aircraft training. Exceptions to this practice may be made if it is determined that a student's progress through a course would be materially aided by a change of instructor. Within SAC and ATC, different instructors are used for the simulator and for the aircraft.

The Strategic Air Command uses qualified aircraft commanders as simulator instructors. These individuals, assigned permanent simulator duty (3 years), conduct approximately 50 percent of the simulator training required for aircrews transitioning into the B-52 or KC-135 aircraft at the SAC CCTS. They also conduct all of the training accomplished in the SAC mobile simulators (pp. 50-54). Before B-52 students enter into the flying training phase, they receive five of the required nine[2] simulator lessons from the permanently assigned simulator IPs. In this phase, students are not matched to any particular IP. Upon entry into the flying phase, however, they are matched with a flightline IP and receive all remaining training, including the last four simulator lessons, from him. In the KC-135 program, matching of students and simulator instructors is practiced, and the students receive the first four simulator lessons from the same IP. Thereafter, flightline IPs give the remaining four simulator lessons, as above.

Within ATC, enlisted men are used as synthetic trainer instructors. They instruct undergraduate pilot trainees on the procedures and instrument techniques which must be mastered to fly ATC aircraft.

One MAC unit, which conducts annual evaluation and refresher training for MAC aircrews (see MACR 50-8), also uses qualified aircraft commanders as permanent simulator instructors. But, unlike

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[2] SAC regulations require a total of only eight simulator lessons. A ninth lesson was added at the CCTS to insure that sufficient time was available to satisfy a recently added requirement to accomplish simulator training on the use of terrain-avoidance radar.

SAC practice, these individuals also fly with their students. Simulator instructors at this unit are also fully qualified Flight Examiners, who use the simulator and aircraft almost interchangeably to assess and correct pilot deficiencies. One of the more modern flight simulators in the MAC inventory, the C-141 simulator is shown in Figures 1 and 2 on the following pages. Figure 1 shows the cockpit interior; Figure 2 shows the simulator instructor work area.

In some cases, the Instructor Pilot works in the simulator with one student at a time. In others, the IP may conduct training for two, or sometimes, three individuals simultaneously. In training copilots for multiengine aircraft, standard practice is to take the trainees through, two at a time. Simulator periods are alternated so that the student will fly each lesson one-half of the time in the pilot's seat and the other half in the copilot's seat. In a least one ADC unit, training practice is to take two or three students to the simulator at the same time. While one student flies the simulator, the other(s) observes. At the completion of each required lesson, students change places.

Teaching methods are varied to meet the needs of individual students and to fit the material being taught. In some cases, the student learns by doing. In other cases, required material is simply demonstrated to him (e.g., see Figure 11 in the Appendix). The Instructor Pilot queries the student to determine his understanding and/or ability to perform the required lessons. In all programs, liberal use is made of the simulator "freeze" capability. Instructor Pilots note that this capability is an invaluable aid for training and for exchange of information.

PROFICIENCY ASSESSMENT

Within Air Force simulator training programs, assessment of student proficiency is mostly an informal process. The principal concern of assessment is with the student's satisfactory progress through, and timely completion of, simulator content. Consequently, rigid grading criteria are seldom employed, with instructor judgment serving as the criterion of acceptable performance on simulator items. Although rarely invoked, provision is included for deficient students to receive additional simulator time at IP option. Given these common bases and purposes, the actual grading practices employed vary considerably among training units, both with respect to the grading system used and the manner of assessment.

Within ADC, students are graded on each of the simulator missions contained in the aircrew training manual (e.g., ADCM 51-101, ADCM

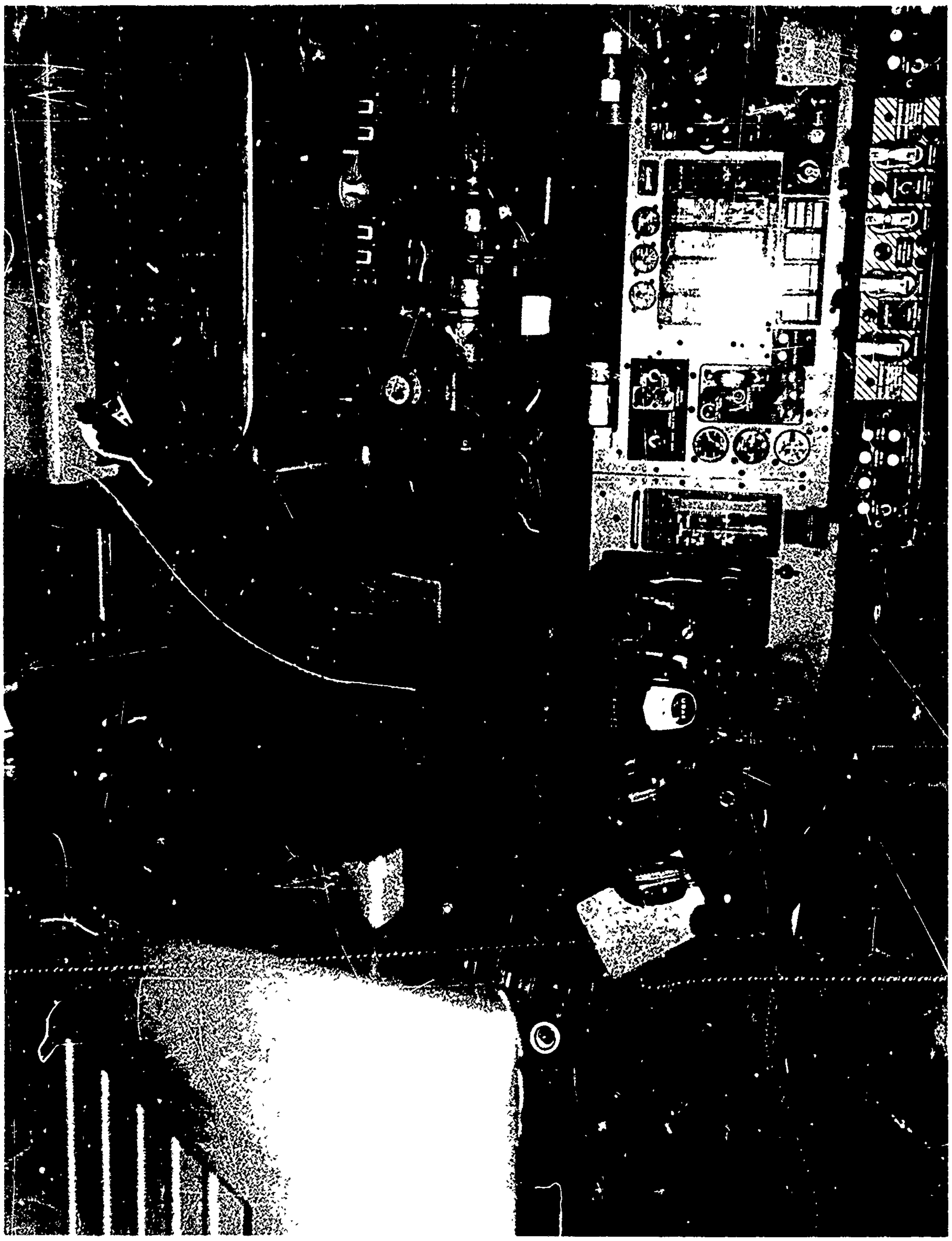

Figure 1. Portion of Cockpit of C-141 Flight Simulator

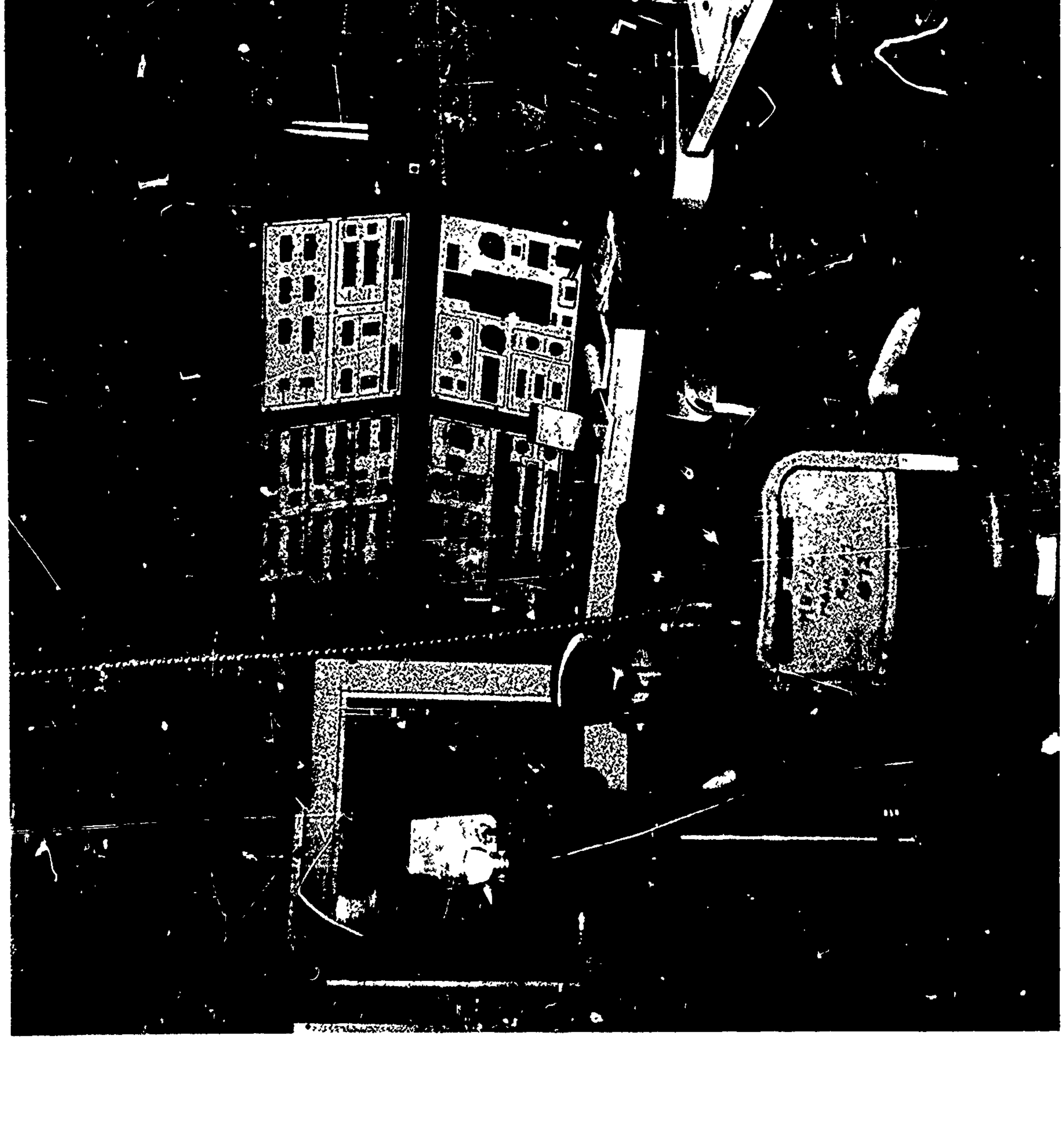

Figure 2. Instructor Area for C-141 Flight Simulator

51-106). Grades are assigned on the basis of performance of the entire lesson rather than on specific items within a mission. A check mark (✓) is entered on the individual's "Interceptor Aircrew Training Record" to indicate the grade received for each mission. Grades assigned consider the grading criteria (established for flight checks) contained in the aircrew training manuals for four levels: Unqualified, Conditionally Qualified, Qualified, Highly Qualified.

Within TAC, the student's proficiency may be assessed on either an overall mission or on specific items within a given lesson. The practice followed depends on the type of aircraft or mission being trained and the particular training site. In some TAC units, student performance is assessed as either satisfactory (qualified) or unsatisfactory (unqualified), reflecting grading practices for standardization/evaluation flight checks. These are contained in Tactical Air Command Regulation 60-2, "TAC Aircrew Standardization Program." The regulation provides (p. 3):

> The following terms will be used to identify aircrew performance and to arrive at the overall grade:
>
> (1) Qualified - An aircrew member who demonstrates the ability to accomplish the given mission safely and effectively. He demonstrates a thorough knowledge of systems, procedures, and the capabilities and limitations of the aircraft.
>
> (2) Unqualified - An aircrew member who is either unsafe or is unable to accomplish the required mission effectively. He requires additional concentrated training under the direct supervision of an instructor.

At other TAC units, the grading system used with the simulator has been expanded for local purposes. One unit grades student performance on specific items as Above Average, Average, Below Average, or Unsatisfactory. Another assigns grades of Unknown, Failure, Acceptable, Good, Strong, or Outstanding. At the C-130 school, student performance is assessed by the IP at the end of each simulator mission as Above Average, Normal, Below Average, or Unsatisfactory. Also, areas needing additional study and/or practice are indicated on the progress record and appropriate remarks are entered. On the last simulator mission (Lesson 10), which is an emergency procedures check, (usually given by the student's IP), overall performance is

assessed as either satisfactory or unsatisfactory and areas where emphasis should be placed during the flying phase are indicated. A portion of the "C-130 Simulator Record of Progress" is shown as Figure 12 in the Appendix.

In MAC training units, student progress and proficiency during the simulator phase of training are recorded on MAC Forms 21 and 21a (Figures 13 and 14 of the Appendix). Form 21a notes the specific items on which proficiency may be evaluated in the simulator. The form contains space for entering the number of times ("N") that the student has performed a given operation and his grade ("G") on it. Grades range from "1" to "6" and are assigned in accordance with the criteria listed on Form 21. These are based chiefly on the amount of assistance the IP must provide the trainee. While at least "4-level" achievement is required for graduation, "5-level" achievement has been established as a training goal. At one large MAC training unit, achievement of a "5" grade on specific items generally means that the student will not be required to perform that item again during training. If the student receives all 5s early in training, proficiency-based graduation (i.e., graduation short of completing the required number of hours of training) may be considered, although this is rare. MAC Form 21 is also used to record the cumulative amount of simulator time the student has received. The back of the form contains provision for recording specific simulator missions and student strengths and weaknesses in their accomplishment.

At the SAC CCTS, student performance is assessed by his IP during each simulator mission. Students are graded on specific items as either satisfactory or unsatisfactory. Rigid grading criteria are not employed and grades assigned are based solely on instructor judgment. The form used in grading also contains space for recording student strengths and weaknesses. Used mainly as a record of progress, these forms are reviewed daily by training personnel to determine if problem areas are building up for particular students. The forms are retained at the CCTS after the student has completed training. SAC Form 128, "Individual Synthetic Trainer Record," is, however, prepared or annotated, as appropriate, for each student. This form reflects accomplishment of required simulator training and is a permanent part of the student's ground training file.

Grading procedures and practices employed within ATC are more formalized and more rigid than those used in the other commands engaged in pilot training. Standardized grading practices contained in the Undergraduate Pilot Training Flight Line Grading Guide (ATC

Instructor Guide 51-111103-3), are used. The Grading Guide requires that grade slips be prepared for each aircraft mission and also for each synthetic trainer lesson. A sample of one type of grade slip used in the program (T-37 Instrument Grade Slip) is shown in the Appendix as Figure 15.

Each lesson outlined in the UPT syllabus (Course Nr. 51-1111038) is graded on an appropriate grade slip. Instructors are directed by the Grading Guide to "evaluate the student's characteristic performance on each individual item or part of each maneuver as well as the overall performance of each maneuver." Results of this "absolute" evaluation are noted in the appropriate block on the grade slip. Under this absolute grading system, the student's ability to perform specific items or maneuvers is evaluated without regard to whether he "has or has not received instruction and practice on a maneuver during previous lessons."

In addition to absolute grading, however, relative grading is also employed. The instructor is directed by the Grading Guide to "determine the overall evaluation grade for a lesson by comparing the student's performance with all other students that the instructor has observed at the same level of training." Because of this procedure, the student "may receive grades of 'fair' or 'unable to accomplish' on individual maneuvers that are relatively new to him and still receive as high as an excellent grade for overall performance." However, any student who has "been graded unsatisfactory in any phase is considered unsatisfactory in that phase until he has performed each maneuver in which he is deficient in an acceptable manner." In addition to the grade slips which are kept in the student's training folder, an "Individual Progress Record" indicating satisfactory accomplishment of each synthetic trainer lesson is also maintained.

Assignment of particular grades is accomplished by reference to established grading criteria. These may be stated as verbal descriptions of performance or they may be expressed in quantitative terms. Representative of the grading criteria used by ATC enlisted Instrument Trainer Instructors are those used at one ATC UPT base. These are shown in Figure 16 of the Appendix.

SIMULATOR PROGRAM SUPPORT

Support considerations which affect the effectiveness and utilization of flight simulators for training are discussed herein.

Program Administration

Administration of simulator training programs is accomplished at the level most intimately involved in their use for pilot training. Local training units, subject to certain Air Force and Command requirements on length and content of training (identified in previous sections), establish the conditions under which the simulator will be used for training, schedule all training periods, and assign individuals to conduct the training. As a general rule, difficulties which might affect simulator utilization or effectiveness do not arise from administrative factors, as corrective action for incipient problems can be taken immediately at the local level.

Scheduling of Training Periods: Scheduling of simulator training periods is accomplished entirely at the local level. All training units are provided fiscal year forecasts of the number of pilots (crews) to be trained during that year. This, plus the requirement for a fixed number of simulator hours per pilot, yields the amount of simulator time required for a given period. The required training is then apportioned among the available simulators assigned to the unit.

At all of the units visited, schedules for simulator utilization are made up by the local activities concerned with the overall training program (i.e., Engineering, Simulator, and Flying Training phases). Thus, variously named units, e.g., Wing Plans, Wing Training, Academics Section, Squadron Operations, etc., may accomplish this function. In all instances, the use schedule for the simulator is developed by activities other than the simulator section. The principal responsiblity of the simulator section is to insure that these schedules are met by making the devices and necessary training support personnel available when they are required. Sometimes, the effectiveness of the flight simulator, and of the section supporting it, may be evaluated in terms of ability to meet these training schedules.

Utilization Reporting: All units which possess flight simulators (and certain other types of training equipment) have been required by the Air Force (AFR 65-45, AFM 65-110) to submit monthly reports reflecting the preceding month's status and utilization of these devices for training purposes. The Air Force is now revising the utilization reporting system. Changes to the system will be contained in an Amendment to Air Force Manual 65-110. The exact nature of the changes are, however, not currently known. But, since it is anticipated that individual commands will retain many features of the current system to fill particular needs, it is described here.

Monthly reports (Reports Control Symbol AF-E7) are submitted by all units on AF Form 451. These are consolidated at Ogden AFB, Utah. A "machine-run," semiannual E7 report is prepared and distributed at Air Force Headquarters levels. This report contains data on flight simulator usage at all possessing units throughout the Air Force. These E7 reports identify each device in a reporting unit's possession, note its status for the month (i.e., A--Device Required, B--Out of Commission, C--Base Storage, D--Excess, E--No Longer Possessed, F--Power Off for Maintenance, G--Research and Development), and the number of hours it was operated each month for training purposes.

Although not used in the consolidated E7 report, space is provided on the reporting form (AF Form 451) for "remarks." These are used by Command units to monitor simulator programs under their cognizance. Typical entries in this column relate to problems connected with maintenance, availability of spare parts, cancellation of training hours, inability to accomplish scheduled training, etc. Figure 17 in the Appendix is typical of the E7 reports submitted by units holding simulators. Figure 18 (Appendix) shows a portion of a page from a consolidated, semiannual E7 report.

In addition to the Air Force-required E7 report submission, certain Commands also require that supplemental information be submitted by simulator units for Command purposes. The Military Airlift Command, for example, requires all training units (MAC Regulation 50-8) to submit quarterly forecasts (E27 Report) of the number of hours that the simulator will be used for training during the upcoming quarter. These forecasts are based on scheduled training requirements for transitioning pilots (see above), plus training hours anticipated to be required for training maintenance technicians, for giving required continuation training for permanently assigned aircrews, and other legitimate training purposes. Whenever actual training hours operated for a month deviate more than 5 percent (in either direction) from the forecast training hours, the reporting MAC unit must submit to Command complete justification for the discrepancy.

Tactical Air Command units submit, with the E7 report, a completed TAC Form 44. These units report both for the current quarter and for the immediately preceding month. The number of training hours required (i.e., to meet training requirements) during the quarter are projected for each device possessed. Of this amount, the number of hours actually scheduled (programmed) for accomplishment and the training hours completed are reported. The availability (in hours) of the device for training during the current quarter is also reported. For

the month, each TAC unit reports the number of hours scheduled and the training hours lost due to student failure to report for training and for other reasons. Justification for loss of training hours and other problems related to device utilization are noted in the remarks column. A typical TAC Form 44 report is shown as Figure 19 in the Appendix.

The Strategic Air Command also requires supplemental utilization reporting by simulator units. SAC Report E2 is prepared monthly and submitted to Command on SAC Form 1048. This report notes trainer operating status, "power on" hours for the preceding month, and the total hours of operation accumulated on the device since installation. Also, the number of hours scheduled per trainer, the number of hours used, and the percentage of the scheduled training completed are reported. An additional column, plus "remarks" space, is provided for reporting training hours lost and reasons for these losses. A typical SAC E2 report is shown as Figure 20 of the Appendix.

Utilization reports, as a group, reflect the number of hours that given flight simulators are operated for all kinds of training purposes. They are also taken to constitute a measure of the effectiveness of devices (and support groups) in meeting training requirements. However, it must be noted that "hours operated for training" includes not only pilot training time, but also maintenance technician training time and device checkout time. In terms of meeting established training schedules for simulators, virtually all Air Force simulator units report greater than 90 percent effectiveness. One large CCTS, in fact, has reported greater than 99 percent effectiveness for its assigned simulators over a five-year period. While such figures are, indeed, impressive, they reflect, in the final analysis, only the relationship between need for the device and its availability for training, thus, reflect ability to meet schedules. These topics are discussed in greater detail in Section III.

Command Support

Within each of the major air command headquarters, certain activities have been delegated responsibility for flight simulators within the command. The function of these headquarters groups is chiefly one of monitoring the simulator program from the standpoint of maintenance and support for training. Command units rarely become involved in the content of simulator training or simulator usage practices by instructional personnel. Chiefly, their function is to insure that adequate training facilities are available to the local units. Headquarters units monitor the E7 reports for identification of problem areas and assist local units in resolving these problems. They also assist in the procurement of additional, and modifications to existing, simulators and in

spare parts procurement. In the context of training support, these command activities also insure that local units are assigned a sufficient number of trained maintenance personnel to maintain the simulators in their possession.

Simulator Section Function and Organization

With a few significant exceptions (one MAC unit, the SAC CCTS, and ATC units), simulator units within the Air Force are organized for the sole purpose of maintaining the simulators and providing support for training operations. These units are responsible for meeting the training schedule established by making the simulator available at the appropriate times and providing enlisted personnel to serve under IP supervision as device operators, radio aids operators, flight controllers, and in whatever other capacities are directed by the IP. Simulator units also prepare utilization reports and various other reports related to simulator maintenance and spare parts procurement.

Some simulator units, in addition to the training support functions above, are also directly involved in simulator training. In one MAC simulator unit, principally concerned with refresher training of air-crews, permanently assigned flight examiners instruct and evaluate pilot performance in both the simulator and the aircraft. At the SAC CCTS, qualified aircraft commanders, assigned permanent duty in the simulator section, instruct portions of the simulator training required for transitioning aircrews at the CCTS, and also instruct on SAC's mobile simulators. Within ATC simulator units, selected enlisted personnel are trained and utilized as synthetic trainer instructors.

Simulator units typically exist as sections within a larger unit, usually a squadron. At one base, however, the simulator unit is a separately constituted CCTS, although its function is limited to training support.

The chain-of-command relationship of simulator sections to the operational training units which use the simulators also varies within the Air Force. Generally, the simulator unit, in parallel fashion to the aircraft training squadrons, reports to the flying training (Wing) commander through intermediate offices including the Deputy Commander for Operations (and/or Training). Within ADC, simulator units usually report to a Combat Support Group under base operations. This is also the case for several simulator units within TAC.

Almost all simulator units have authorization for and have assigned OICs to supervise simulator operations. One large training unit within

TAC, however, has no authorization for a simulator OIC with this function assigned as additional duty to flying officers who assist the senior NCO supervisor. As a general practice, most training units assign certain IPs additional duty as simulator officers. These individuals perform liaison with the simulator unit and also accomplish the important function of checking out the simulator after all major repairs or modifications. This is to insure that such operations have not seriously affected the training device's simulation of the aircraft.

Maintenance Support for Training

Although the present study is not directly concerned with maintenance of flight simulators per se, a number of considerations arose during the structured interview sessions concerning maintenance-support-related factors which have implications for training efficiency. Thus, to provide material for a subsequent discussion of these points and for presentation of the views of Air Force training personnel toward simulator maintenance factors (in Section III), certain background information is presented here under two topics: maintenance personnel and logistics.

Maintenance Personnel: Simulator maintenance personnel (Flight Simulator Specialist/Technician, AFSC 342x0) receive formal training (at Chanute AFB, Illinois) as prescribed in Air Force Manual 50-5, USAF Formal Schools Catalog. The fiscal year 1967 projection by Headquarters ATC was for 195 students to attend the 36-week basic course. The content and prerequisites for these courses are excerpted below.

ABR34230 - Flight Simulator Specialist - DOD191 - Cat A
Chanute/36 wk - Oct 66

Maintenance, repair, and operation of flight simulators. Electrical and electronic principles required for circuit analysis of electronic analog and digital computers, system operation procedures, and troubleshooting and testing procedures. Analog and digital computer principles, circuitry operation, maintenance management (AFM 66-1), and operation procedures applied to flight and navigation problems.

Prerequisites: Min aptitude cluster percentile Elct 80 mand. Normal color vision and speech. Min phys profile serial 222121 desirable. High sch grad or equiv with math background thru algebra very desirable.

AAR34270 - Flight Simulator Technician - DOD191 -
Chanute/21 wk - Jul 66

Organizational and field maintenance of flight simulators, weapon systems training sets, and mission simulators. Familiarization with advanced theory in electronic principles required for circuit analysis of electronic analog and digital computers; systems operational procedures; identification, location and inspection of systems components; systems troubleshooting and testing techniques; and calibration and maintenance techniques.

Prerequisites: Qualified in AFSC 34250, 34151, 34350, 34450, or higher. Minimum of 3 years progressive experience performing field or organization maintenance in the specialty, which may include experience in both the 3- and 5- levels of the AFSC. Normal color vision and speech. High school graduate or equivalent with mathematical background thru algebra very desirable. Civilians must have a minimum of 3 years experience in actual performance of repair and maintenance of flight simulators.

Following graduation, trainees are assigned to various bases to support trainer operations as maintenance technicians. Certain individuals, however, (e.g., those high in class standing), are reassigned to ATC bases as procedures trainer instructors (see p. 48 below).

At his assigned base, the new technician begins an intensive OJT program under the supervision of more experienced men. This OJT program is conducted according to the applicable Job Proficiency Guide (JPG) for his specialty. The JPG, based on the Specialty Descriptions outlined in AFM 39-1, lists the tasks required for an airman to become proficient in his assigned duties and the governing directive or technical publication applicable to each task, plus the degree of proficiency required at each skill level. One maintenance supervisor noted that at least four months are required for an individual to become competent at his job.

Besides performing normal maintenance duties, enlisted personnel assigned to the simulator section also provide direct assistance during training sessions. These personnel serve under IP supervision as device operators, GCA controllers, control tower operators, and in other capacities requiring simulated voice communication/instruction during the training session. As preparation for this role, selected individuals are given informal OJT. At most units, this consists chiefly of observing

an experienced man and trading off with him as controller. At some bases, this practice is supplemented by visits to the base control tower and observation of controllers at work.

Logistics: Logistics support for flight simulators involves the two primary considerations of procurement of spare parts and modifications for updating devices to current model aircraft configurations and/or performance characteristics. Both factors have implications for the effectiveness of simulator training insofar as they affect the fidelity with which components of flying can be represented in the simulator. Spares procurement for simulator usage normally proceeds through established supply channels, but most simulator maintenance units have also been granted local purchase options to obtain certain urgently needed components. Authorization has also been granted in most cases for the local units to effect needed modifications within their capabilities. While such measures have solved many of the traditional problems associated with support of training equipment, a number still remain. These will be discussed in Section III.

SIMULATOR INSTRUCTORS

Individuals who instruct pilots on flight simulators are the topic of this part of the report. Selection, training, and quality control of Instructor Pilots and ATC enlisted instructors are described.

Instructor Pilots

Within the Air Force, an individual Instructor Pilot is directly responsible for conducting all flying training that a particular student receives. In addition to his primary job of training the student to the required level of proficiency in the air, he is also usually responsible for his simulator training, as this is a part of the overall training program. Selection, training, and quality control of Instructor Pilots throughout the Air Force are based on the IP's ability to fly the particular aircraft and to transmit the skills, knowledge, and experience gained, and maintained, in the aircraft to others. These practices, thus, are geared in a most primary way for the airborne environment and in secondary ways for the ground environment of which the simulator is a part. However, in keeping with the stated purposes of the present study, the discussion herein is focused, insofar as possible, on selection, training, and quality control practices as they pertain to simulator usage by IPs rather than on the aircraft domain.

Selection: Each Air Command is responsible for the selection and assignment, on a regular basis, of qualified individuals for instructor pilot duty within the Command. Usually, the major selection criterion is the level of competency that the individual has achieved in the aircraft. Competency, in this context, is often defined in terms of a specified number of hours of flying experience. For example, IPs for the C-130 aircraft are required (AFM 51-130, p. 10) to, "have a minimum of 2000 hours total time and at least 200 hours first pilot time in the C-130 aircraft or 1500 hours total time and 500 hours first pilot time in the C-130 aircraft." The number of flying hours required varies depending on the aircraft type and mission. Potential F-101 IPs are required to have 1000 hours total flying time and 100 hours F-101 time (ADCM 51-101, p. 4-4). F-106 IPs must have 1000 hours total flying experience, at least 500 hours total jet aircraft flying experience, and 200 hours total F-106 experience, plus a current instrument rating (ADCM 51-106). Potential IPs for TAC reconnaissance aircraft (RF-4C, RF-101, RB-66) must be designated combat ready and have at least 150 hours flying experience in the appropriate aircraft (363d TACW, DCO OI 55-16). ATC generally selects top students from current UPT classes to serve as IPs within the Command.

In addition to, but highly related to, the requirement for achievement of a certain number of hours flying experience, potential IPs must also be currently designated as fully qualified aircraft commanders, or first pilots, (as applicable to the aircraft). Special provisions are made within SAC, however, to permit copilots assigned to numbered tactical crews to instruct student copilots undergoing initial qualification training only. These individuals must be designated as instructor copilots on special orders, have a current, formal standardization check as a combat-ready or higher category copilot and have at least 200 hours pilot and/or copilot time in the aircraft (SAC Regulation 60-7, Vol. I, Instructor Duties and Minimum Qualifications for Aircrew Positions, p. 2). Currently, most IPs assigned within TAC have completed a combat tour in Southeast Asia.

Other criteria are also employed in selecting pilots for instructor pilot duty. These are summarized in the excerpt below. Although the material is from MAC Regulation 51-2, Aircrew Instructor Program, and is specific to the Military Airlift Command, the criteria are representative of those used throughout the Air Force for Instructor Pilot selection.

Qualifications

Unit commanders will review personally the qualifications of each aircrew member considered for instructor appointment

to insure they possess all required qualifications. The following qualifications are established as prerequisites for appointment.

a. Instructing Ability. An instructor is basically a teacher; therefore, he must qualify under recognized teacher standards. He must be capable of imparting knowledge to others, utilizing the principles of instruction outlined in AFM 50-9, How to Instruct.

b. Judgment. Must possess judgment necessary to meet unexpected or induced emergencies. Ability to exercise sound judgment in flying activities through mature realization of his own, his students' and the aircraft's limitations are required.

c. Personal Qualities. Should have a desire to instruct others. He must have patience, tact, understanding and ability to foresee results of present acts or mental attitudes. Instructors must have a personality that inspires and wins respect of each student.

d. Technical Knowledge. Must be thoroughly familiar with respective aircraft's systems and equipment, normal and emergency operating procedures, and for pilots and engineer/mechanics, the prohibited maneuvers and aircraft performance under all allowable conditions of flight.

e. Flying Proficiency. Individuals selected must be fully qualified and current in specific model aircraft.

f. Flying Experience. Instructors must possess a reasonable background of flying experience to have developed desired standard of knowledge, judgment and proficiency. Normally, these qualities progress together. However, flying hours alone cannot be accepted as criteria for any one or all qualities.

The decision to assign an individual to IP duty is usually made by the major command. Provision is made, however, to enable qualified individuals to request this duty. Also, training units may request

Command to assign an individual (by name) to the unit as an Instructor Pilot. The tour of duty for IPs is a minimum of one year and, generally, a maximum of three years.

Training: At all training units visited, a program of instruction is in operation for upgrading qualified pilots to IP status. The principal objective of these programs is to qualify the student IP for aircraft instruction duties. However, most also include practical experience in simulator instruction and in the techniques and principles of instruction. Within some commands (notably, SAC and ATC) formal schools are established for IP upgrading and all IPs within the command are required to be graduates of the school. MAC conducts an Instructor Pilot seminar and requires its IPs to be recent participants. While ADC has formal instructor courses, waivers may be obtained based on local needs. Like TAC units, ADC local training units provide instruction to qualify assigned pilots as IPs.

The Strategic Air Command conducts a Central Flight Instructors Course (CFIC) at Castle Air Force Base, California. This 2-week course, prescribed by SAC Regulation 60-7, Volume II, is required for all SAC IPs. The content of the course, in brief, is as follows:

a. Academic Training (23 hours)

Subject	Hours
Introduction	1:00
The Flight Instructor	2:00
Principles of Instruction	3:00
Motivation	2:00
Regulations and Manuals for the Flight Instructor	4:00
Student-Instructor Relationships	4:00
Evaluation and Student Training Records	2:00
Seminar	4:00
Course Critique	1:00

b. Synthetic Training:

CFIC students will gain instructor practice by alternating between pilot and copilot seats, providing each with two hours to instruct from the right seat, as required in flight. Simulator training will include maneuvers stressed in the CFIC program. Simulator course by aircraft is as follows:

Type	Number of Missions	Hours
B-52	1	4:00
KC-135	1	4:00

c. Flight Training:

B-52/KC-135 crew complement will consist of CFIC instructor and two student instructors. The purpose of the sortie is to provide the student instructors the opportunity to practice instructing in all phases of flight including flight characteristics and touch-and-go landings. Flight training requirements are:

B-52 - (2) missions - 12:00 hours.
KC-135 - (2) missions - 12:00 hours.

In both the simulator and flying phases, each student receives instructional experience. This is accomplished by having one student serve as instructor for the other for half of each mission. The experienced CFIC instructor observes, evaluates, and critiques their performance as instructors.

The material presented in SAC Regulation 60-7, Vol. II, for academic instruction of IPs refers extensively to use of the flight simulator in pilot training. One section, under "Principles of Instruction," is especially cognizant of the simulator's potential for pilot training. Excerpts from this section (pp. 15-22, SAC Regulation 60-7, Vol. II) are given below:

Directing Learning for Performance
Time: 2 Hours

1. Objectives. The instructor will be able to explain:

a. The seven uses of the simulator to improve performance and increase safety.

b. The advantages of simulator training for the instructor and student.

c. The three phases to performance training and the teaching techniques to use in each phase.

d. The techniques to employ and importance of a demonstration to a student.

e. The analysis technique of analyzing and correcting student errors.

2. Outline:

a. The Importance of the Simulator in Aircrew Training

(1) To minimize the expenditure of flying hours for aircrew proficiency training. In most aircraft, one simulator mission is as good or better for student training as one airplane mission. This is true up to a point where the student knowledge/proficiency makes the individual safe to begin airplane training. In many instances, an airplane readiness check is performed (required) by the student which determines his readiness to progress to the airplane. (Ask instructor trainee about how many simulator missions were profitable before going to the aircraft, for him.) This can go as high as seven or eight missions (EB-47 program) to four or five missions (B-58 program), to no missions for local checkout of support aircraft.

(2) Gives the instructor an opportunity to concentrate the training in the area(s) of greatest difficulty. Since the instructor has complete control of the simulator and environment, he can tailor the training to the needs of each student to best overcome any problem encountered by the student.

(3) Can best develop new responses and procedural training. You can slow the training down to insure proper use of procedures and correct responses to cues. Also, you can teach proper responses to locations of switches, clock, dials, etc. When mistakes are made, he can immediately repeat to correct responses before they become fixed in an incorrect manner.

(4) The instructor can tailor the facilities to provide continuous progress for his student. He has time to find out what the student knows or does not know and so plan the training for him. He can provide for increasing difficulty and workload as the student progresses.

(5) It provides an opportunity to teach several maneuvers and procedures that are not taught in the airplane (for reasons of safety). For example, many emergency procedures can be done safely in the simulator but not in the airplane. Other maneuvers as simulated stalls, spins, unusual attitudes, certain engine-out procedures, etc.

(6) Provides a means for easily repeating maneuvers or procedures that are missed or performed incorrectly for some reason. These can be practiced without danger to personnel or equipment. An excellent place to teach the check lists (both expanded and consolidated check lists - normal and emergency procedures).

(7) All of the above will save us accidents which might have occurred while learning fundamentals of airplane and procedures. If the simulator instructor is also the flight instructor (and this is recommended) safety is further enhanced as the instructor knows the student's weaknesses and can better protect himself and the student.

b. Advantages of the Simulator. The simulator offers several advantages over the airplane for teaching and learning.

(1) The instructor can best plan the training on an individual basis for optimum learning.

(2) He can devote his full time to instructing.

(3) He can give more attention to motivation for the student.

(4) The mission sequence can be developed for maximum effectiveness.

(5) Success, which is important for student progress, can be reasonably assured.

(6) Repetition can be given as needed.

(7) Errors can be corrected when they occur.

(8) Bad habits and responses can be eliminated.

(9) Time is available to reward good performance.

(10) Time is available to prepare for problem solving.

(11) Self-initiative can be developed.

(12) Time is available for analyzing and discussing problems as they arise.

At the SAC CCTS, all individuals who instruct on simulators are fully qualified aircraft commanders (as required by SAC Regulation 50-46). This is true of both the permanent simulator IPs, who instruct only on the simulator, and of the flightline IPs who instruct on the simulator and also in the aircraft. Prior to assignment to the CCTS, by SAC Headquarters, these individuals have previously been IPs within SAC. Since they have completed the CFIC at some time in the past, the training given them at the CCTS is principally refresher training on instructional techniques.

Individuals assigned as simulator IPs begin instructional duties almost immediately. The general procedure is that they first observe an experienced simulator IP instruct three missions in the simulator. After this, the "student" IP instructs three missions and is observed and critiqued by an experienced IP. When this is satisfactorily completed, he begins independent instructional duties.

A similar training procedure is followed for the flightline IP. Student IPs practice instruction under the supervision of a more experienced IP. Generally, this involves four to five aircraft rides. Also, the student IP is checked out on the simulator by an experienced IP. He is then given a student class to instruct.

The Air Training Command also conducts a formal school for Instructor Pilots. Currently, the Pilot Instructor Training School is located at Randolph Air Force Base, Texas, but is scheduled to be relocated in the near future. Successful completion of the school is required for all ATC IPs. Length of the course for both T-37 and T-38 IPs is 42 training days (approximately ten calendar weeks).

Rated Air Force pilots assigned by ATC for subsequent IP duty in the T-37 aircraft receive the training outlined in ATC Syllabus Nr. 51-111507Q. Currently, this consists of:

1. Flying Training Subjects:	Approximate Hours Flying	Total
a. Flight Indoctrination	-	20*
b. Contact Flying	30:30	61
c. Instrument Flying	15	30
d. Formation Flying	8:30	17
e. Navigation Flying	6	12
f. Synthetic Instrument Trainer (T-4 or ME-1)	-	6:30
	60	146:30

2. Academic Training Subjects:	Approximate Hours
a. Aviation Physiology	3
b. Principles of Instruction	15
c. Aircraft Engineering	11
d. Applied Aerodynamics	18
e. Instrument Procedures and Radio Aids	8
f. Flight Planning	13
g. Flying Safety	3
h. Written Proficiency Examination	3
i. Course Critique	2
	76

3. Officer Training Subjects:	Approximate Hours
Orientation and Processing	2
	2

Pilots assigned for subsequent T-38 instructional duty receive training in accordance with ATC Syllabus Nr. 51-F111538Q. This currently consists of:

1. Flying Training Subjects:	Approximate Hours Flying	Total
a. Policies and Procedures	-	26**
b. Contact Flying (T-38)	24:40	41:25
c. Formation Flying (T-38)	15:35	28:20
d. Synthetic Instrument Training (T-7 or T-26)	-	10
e. Instrument Flying (T-38)	17:30	30
f. Navigation Flying (T-38)	7:15	10:15
	65	146

*Includes 4 hours synthetic trainer (T-4 or ME-1).

**Includes 5 hours procedures trainer (T-7 or T-26).

2. Academic Training Subjects:	Approximate Hours
a. Principles of Instruction	16
b. Aircraft Engineering (T-38)	12
c. Applied Aerodynamics	15
d. Instrument Procedures and Radio Aids (T-38)	9
e. Flight Planning (T-38)	9
f. Flying Safety	3
g. Course Critique	2
	66

3. Officer Training Subjects:	Approximate Hours
Orientation and Processing	2
	2

As part of both courses, all instructor students are "given guidance in motivation techniques, psychological factors in learning, developmental teaching, counseling, student/instructor relationship, handling emotional students, and techniques in building student confidence." The principles of instruction described in Air Force Manual 50-9, "How to Instruct," are employed throughout these programs.

Instructional experience is also gained by student IPs at the school. A practice teaching procedure is used for this purpose. Of the two students who undergo training as a team, one instructs the other on an alternating basis. The student designated as instructor for a particular mission plans the mission, accomplishes all briefings, flight instruction, error analysis, and critiques. These team missions are also graded by one of the trainees following ATC grading practices to familiarize the student IPs with these procedures. Experienced instructors serve as evaluators of student performance.

During the synthetic trainer portion of the syllabus, similar procedures are followed. The IP receives practice in operating the trainer console and in instructing on the trainer. The student IP instructs his teammate on some lessons and instructs an enlisted trainer instuctor on others. In either case, the enlisted instructor points out deficiencies to the IP in either his instructional techniques or in his operation and management of the trainer console. Although IPs do not normally instruct on ATC's synthetic trainers at the present time, they are prepared for this role when they leave the Pilot Instructor Training School.

The Military Airlift Command conducts a two-week IP seminar course at Command Headquarters. Academic subjects include principles and techniques of instruction, psychology of learning, etc. Attendance of MAC IPs at this seminar is mandatory if they have not completed the course within the three years immediately preceding their assignment to a Technical Training Unit (TTU) for instructor pilot duty. TTUs also conduct training for newly assigned IPs. The training given by these units is principally for instructor standardization. Basically, it consists of observation of the teaching of an experienced IP for one or two simulator periods followed by two periods during which the student IP instructs under the supervision of a more experienced IP. During the simulator periods, the student IP is also checked out "on all facets of trouble console operation and radio aids capability."[3] Appropriate similar instruction is, of course, also given in the aircraft. At some point during his training, the student IP is given standardization flights in the simulator and in the aircraft. In both instances, these are Instructor Pilot evaluations performed while he is instructing student pilots.

Training of Instructor Pilots within ADC and TAC occurs more at the local level than at schools established by Command. Pilots assigned to ADC training units for IP duty receive a series of upgrading rides (usually four) in the aircraft. The last ride in the series is an evaluation check ride during which the student IP flies in the back seat of the aircraft. This may be given by another IP or by a Flight Examiner. Also, the student IP must pass a written proficiency examination within criteria outlined in the ADC Aircrew Training Manuals (e.g., ADCM 51-101, ADCM 51-106). Although it is desirable that IPs have completed the Command's Instructor Weapon School and the Instructor Pilot Instrument School, it is not mandatory that they have done so.

Training of IPs within TAC is also accomplished at local levels. Generally, this training proceeds in accordance with syllabi established for this purpose and emphasizes flying aspects. One TAC CCTS, training pilots for multiengine aircraft duties, requires student IPs to complete the same course as regular students. Other units have developed syllabi expressly for IP training.

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[3] Wing Regulation 50-8, Hq., Military Airlift Wing, Tng (MAC), Tinker Air Force Base, Oklahoma, 22 April 1966.

F-4 units sequence potential IPs through a syllabus requiring 20 aircraft rides,[4] the last of which is a check ride. Missions flown include aerial combat tactics, instrument flights, aerial refueling, transition, gunnery, etc. The intent is to have the student IP fly all of the missions on which he will subsequently instruct student pilots. During this training, the student IP briefs the missions and flies in the back seat of the aircraft to instruct an experienced IP flying the other position. The experienced IP critiques and evaluates the student's handling of the mission. The final aircraft ride, which may be on any type of mission, is a standardization/evaluation check ride. The stan/eval pilot flies the front seat on directions from the student IP and evaluates him as an IP. Upon successful completion, the student is placed on orders and assigned duty as an IP. Figure 3 is an exterior view of the F-4 flight simulator. Figure 4 shows a portion of the monitor console for this device.

At one TAC training site, a formal Aircrew Instructor Upgrading Course is conducted for all newly assigned IPs. Course instructors are limited to the squadron stan/eval Flight Examiner and not more than two of the most highly qualified IPs who must be personally approved by the Deputy Commander for Operations (DCO OI 55-16).[5]

This unit trains pilots for three different types of aircraft (RB-66, RF-101, RF-4C); hence, much of the IP's training centers around the particular aircraft system in which he is rated. A common Academic Instructor's Course, however, is required for all IPs before training in their squadron of assignment begins. This course covers the following material:

Subject	Hours
Psychology of Learning:	6:00

Traits and qualifications of an effective instructor and his use of the developmental approach to teaching concepts, such as patterns and laws of learning, the effects of motivation and the importance of complete subject comprehension as necessary to meet individual student differences.

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[4] At the present time, this is being shortened to qualify sufficient numbers of IPs to meet heavy training requirements.

[5] 363d Tactical Reconnaissance Wing, DCO OI 55-16, Deputy Commander for Operations, Operating Instruction No. 55-16, Shaw Air Force Base, South Carolina, 17 September 1966.

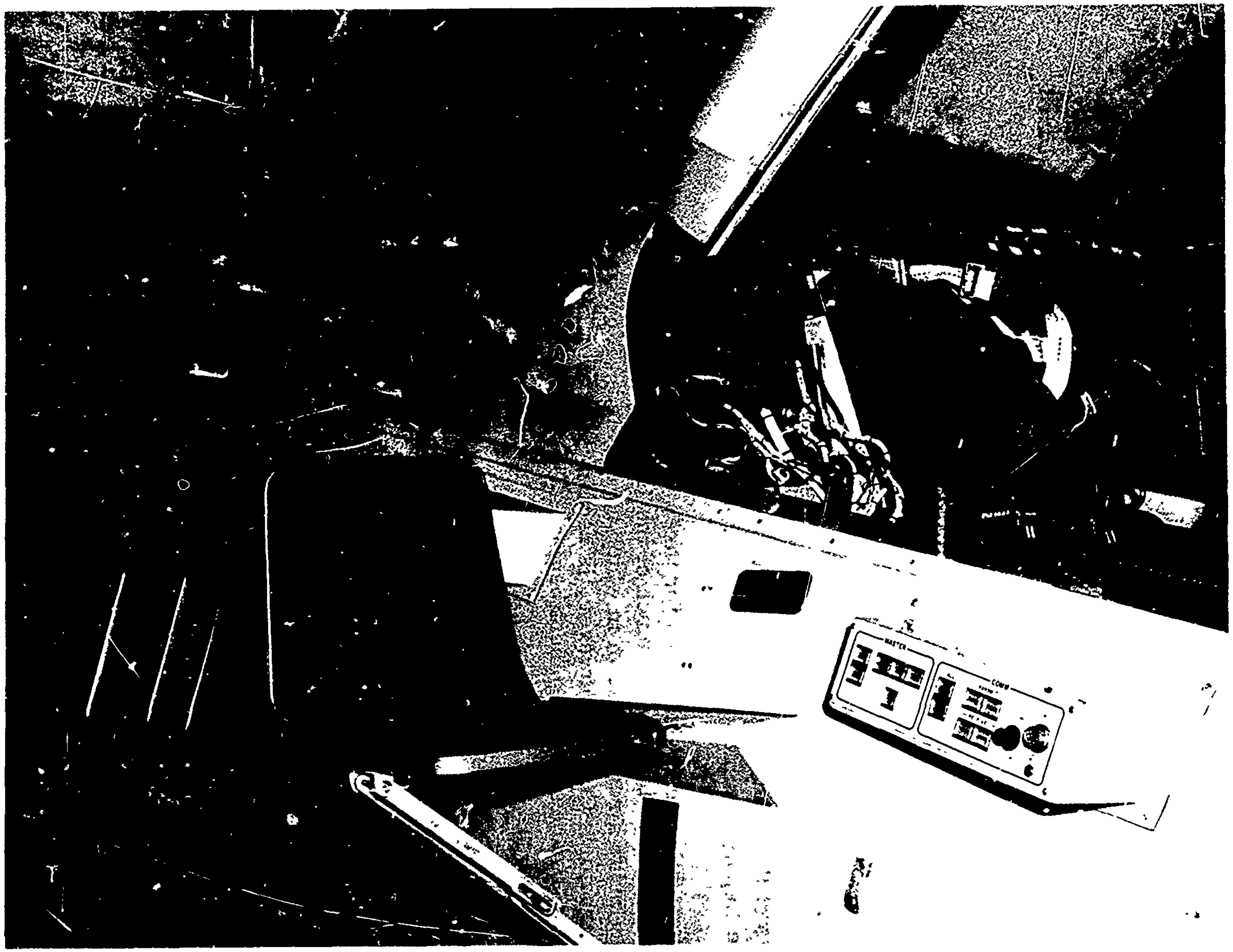

Figure 3. Exterior View of F-4 Flight Simulator Cockpit

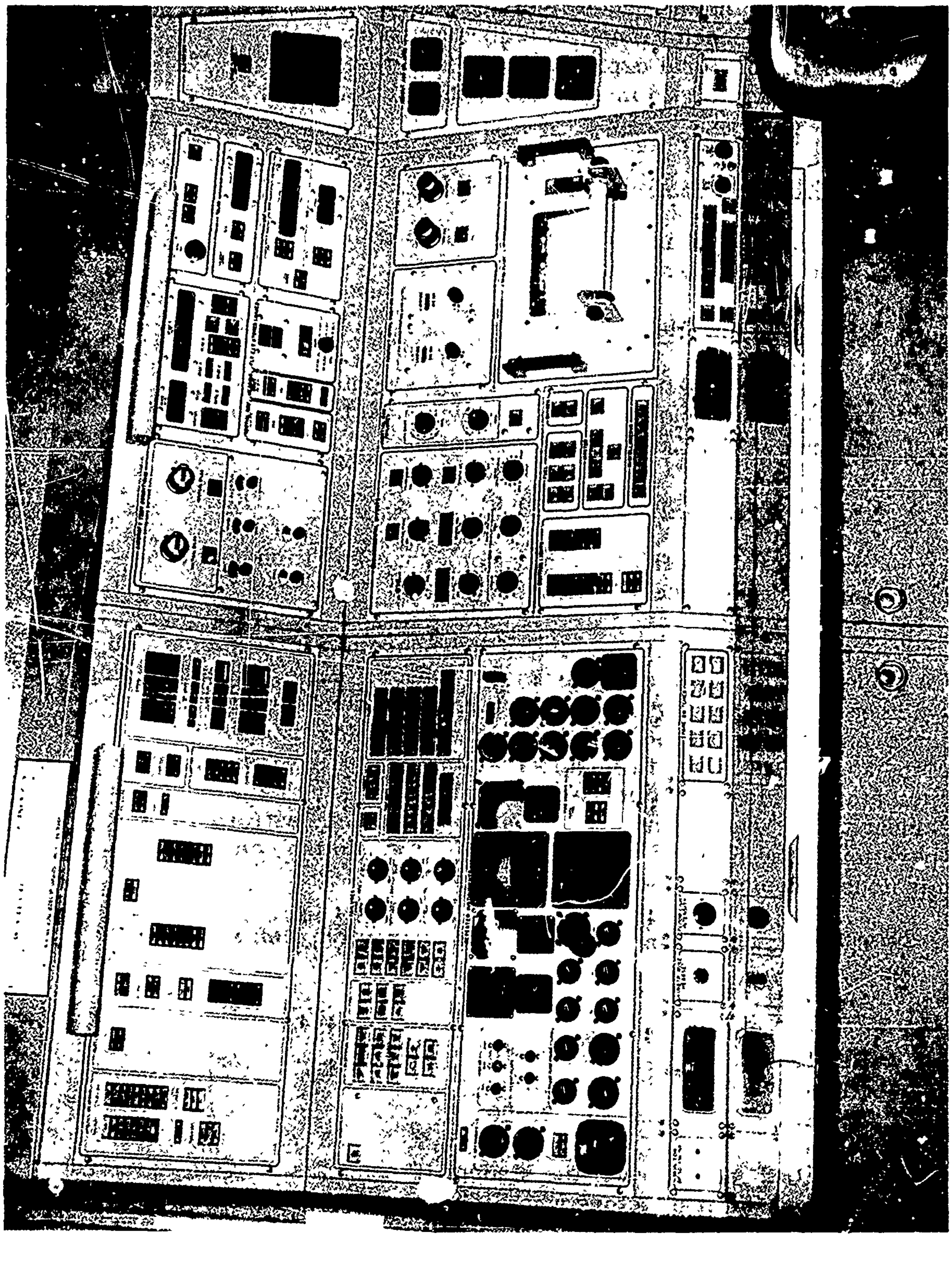

Figure 4. Portion of Monitoring Console for F-4 Flight Simulator

Oral and Written Communication: 7:00

Explains the need for simplicity, directness and clarity in speech to include a discussion of the characteristics of good oral expression. Characteristics of effective writing to include the instructor's role in Air Force writing.

Methods and Techniques of Instruction: 7:00

A study of instructional methods to include the use of lesson plans and training aids.

Evaluation and Measurements: 4:00

A study of the needs and requirements for testing devices, to include test construction, and the administration and critique of examinations.

Course Evaluation and Critique: 3:00

Includes a final examination, course critique and practical exercise.

After successful completion of the Academic Instructor's Course, the student IP receives eight hours of "Squadron Specialized Training" which covers grading practices and forms, student status charts, squadron training procedures, and standardization training procedures. Also, each IP receives two hours training on the appropriate aircraft simulator. This instruction is on "methods of inducing problems to student pilots" and covers "an explanation and demonstration of the operation of the Flight Simulator Panel to include the conduct of required missions, problems, and desired results."

The following flying instruction is currently given student IPs:

Aircraft	Hours	No. of Missions
RF-101	21:10	11
RB-66	20:00	7
RF-4C	22:00	11

For all three aircraft, the student IP assumes the role of instructor. Experienced instructors who fly under direction of the students,

critique and evaluate their performance. Also, the final aircraft mission is an Instructor Pilot stan/eval check ride. Following successful completion, the student IP is placed on orders and begins instructional duties in the squadron.

Quality Control

Although training practices in qualifying pilots for IP duty show diversity throughout the Air Force, quality control procedures are basically similar. For obvious rasons these procedures are keyed to the aircraft rather than the simulator. All IPs are required to remain current in the aircraft (by completing at least one flight per specified period of time), comply with all provisions of AFM 60-1, successfully complete an annual written proficiency examination ana an annual stan/eval flight check. In some cases the flight check is an instructor pilot evaluation (depending on the command and specific aircraft). Usually, however, its intent is to assess the individual's competence as a pilot and rigid and formal procedures are employed.

Quality control, as it relates to the IP's use of the simulator and/or instructional techniques in training, is less formal. Observation of an IP's technique in use of the simulator and attendance at his briefings, etc., by other [illegible]s, supervisors, or stan/eval personnel are principal means employed.

All training units also make provisions for students to critique and evaluate the course of instruction and the instructor. These critiques differ widely in form and content among the various training units. Items may relate to the fidelity of the simulator, content and sequence of training, quality and style of instruction, availability of facilities, etc. Students may be given the opportunity to rate the instructor on personal qualities such as personal appearance, correct pronunciation and use of language, volume and rate of speaking, courtesy and tactful control of the teaching situation, attitude toward teaching, patience when answering student questions, sincerity in his attempts to help the students, etc. He may also be evaluated by his students on his ability to initiate and sustain motivation, knowledge of subject matter, quality of briefings, emphasis of important points, adequate answering of student's questions, etc.

Principally, these critiques are used by a specific training organization for self-improvement. Before disposition, they are reviewed by the responsible training personnel to determine if areas exist anywhere within the program where improvement is indicated. To the

extent that they bear on an individual IP's capabilities or instructional techniques, they may also be reviewed by him and/or supervisory personnel in the interest of effecting changes.

ATC Enlisted Instructors

Currently, ATC has authorized the use of enlisted personnel as instructors for the synthetic instrument trainers used in Undergraduate Pilot Training programs. These individuals are trained as Flight Simulator Specialists (i.e., maintenance technicians). Selected individuals are chosen from current classes and recommended to the gaining unit as procedures trainer instructors.

No formal course of instruction has been established for these individuals but all receive informal OJT at their unit of assignment. This occurs chiefly under supervision of experienced (enlisted) instructors for a three-month period. Before the individual is permitted to instruct on an independent basis, however, his competencies are evaluated by the standardization/evaluation function. Form 610C (Figure 21 of the Appendix) is one of the items used for this evaluation. The instructor is evaluated both on his ability to fly the trainer and on his ability to instruct from outside the cockpit. ATC Manual 60-2 (ATC Standardization/Evaluation Program, 1966) establishes criteria to be used by the evaluator in making this check. As a minimum, the instructor must thoroughly understand the mechanics of maneuvers or tasks, why given maneuvers or tasks are taught, and how to instruct these. During the check, ability to analyze flying deficiencies and impart constructive corrective action is emphasized.

Each enlisted instructor is reevaluated in the same way on an annual basis by the stan/eval function. Also, periodic checks may be given by his immediate supervisor. If, at any time, his "flying" proficiency or instructional efficiency falls below acceptable standards, he is removed from this duty.

COST OF SIMULATOR TRAINING

The capability of simulators to provide training at relatively low cost in relation to costs connected with training in operational aircraft has often been cited as a major justification for their use in pilot training. Acutal cost data, however, have not been generally available to substantiate this claim. As part of the survey, such information was solicited from training units and some limited data were obtained. These are reported here.

The SAC CCTS at Castle Air Force Base computed the average operational cost per training hour for the four B-52 and three KC-135 simulators assigned to and operated at the school during calendar year 1965. Computations were based on UMD authorizations, supply records, and data furnished by the Castle AFB comptroller. Initial cost of the devices was not used in computing the averages. A summary of data provided by the CCTS is shown below.

B-52 Flight Simulator

Hours Operated		2,619
Total Cost		$65,283.97
Cost Per Hour		$ 28.39
Cost Breakdown:		
Wages		$53,757.88
Parts		$ 6,943.47
Power		$ 1,663.20
Housing		$ 2,919.42
	TOTAL	$65,283.97

KC-135 Flight Simulator

Hours Operated		2,599
Total Cost		$74,557.88
Cost Per Hour		$ 28.69
Cost Breakdown:		
Wages		$53,757.88
Parts		$17,500.00
Power		$ 1,000.00
Housing		$ 2,300.00
	TOTAL	$74,557.88

Although no exact data were obtained on hourly cost of operating the aircraft involved, estimates were that the cost of a simulator training hour was approximately one to two percent of the cost of operating the

aircraft for one hour. Costs of operating the mobile flight simulators were also computed for the same period of time. For five B-52 mobile simulators, the average cost per hour of training operation was $83.03. For three KC-135 mobile simulators, average hourly cost was $67.47. These figures include costs associated with personnel, simulator operation and parts, railcar expense and transportation. The precise computational methods used in arriving at the above "average" figures is, however, unknown.

Estimates of the cost per hour of simulator training were also obtained at one MAC training unit. The initial costs of the simulators involved in this study (three different multiengine aircraft simulators) were amortized over a ten-year period, and costs of maintenance, parts, and salaries were included. On these bases, this unit estimated that each hour of training use of the simulator cost $200. One hour of aircraft operating time, averaged over all types of missions, was estimated at $800.

STRATEGIC AIR COMMAND MOBILE SIMULATOR PROGRAM

All B-52 and KC-135 pilots and copilots are required by SAC to receive recurring simulator training throughout each year. This training, specified by SAC Manual 50-24 (Ground Training Requirements), is aimed chiefly at insuring proficiency on emergency procedures, especially landing and takeoff emergencies, for the particular aircraft. SAC requires that each crewmember fly four, 2 1/2-hour-long missions every six months (two missions per quarter) in the appropriate simulator. Two of the missions must be devoted to emergency procedures training and one to instrument training. The remaining mission may be used for either purpose at the discretion of the unit commander. For the B-52 aircraft, it is also required that terrain-avoidance procedures be practiced for 30 minutes on three of the simulator missions.

To accomplish these training requirements, SAC has devised a mobile simulator program. Flight simulators for the KC-135 and various models of the B-52 aircraft, mounted in railcars, travel to the various SAC bases to impart the required training. Currently, SAC has in its inventory nine trains with KC-135 simulators installed and nine with B-52 flight simulators. Twelve of these trains (six KC-135 and six B-52) are manned and maintained by Castle Air Force Base; the other six are manned and maintained by other bases but are scheduled by Castle to meet local unit training requirements.

A B-52 mobile simulator is contained in the railcars shown in Figure 5. Figure 6 shows the cockpit interior of a KC-135 mobile flight simulator. The magnitude of the SAC mobile simulator program is revealed in figures compiled for calendar year 1965 by Castle Air Force Base. These figures show that five mobile B-52 simulators traveled more than 76,000 miles during 1965 and were operated for a total of 14,308 training hours. Three KC-135 simulators traveled 22,275 miles. Training hours operated for these three devices totaled 9,452 hours.

Administration of the mobile simulator program and use of these devices is governed by SAC Regulation 50-46 (Crew Training Devices). SAC Headquarters designates the bases whose training needs will be supported by the mobile simulators (host bases) and the bases that will support the mobile simulators. Also, SAC Headquarters has overall responsibility for coordination with Depot and U.S. Army Transportation Material Agencies in support of the program and for surveillance of the movement schedule to assure maximum support of training requirements. The parent numbered Air Force of the supporting base is required to schedule simulator movement in support of training. Supporting bases operate and maintain the assigned mobile simulators in accordance with numbered Air Force schedules. This includes providing necessary personnel, supply, and logistic support.

Between-station moves of each simulator must be accompanied by at least one onboard officer or airman attendant. This individual is responsible for monitoring all aspects of the movement while the simulator is en route. Upon completion of the move, he prepares a move report which is submitted to the OIC of the Flight Simulator Section of the supporting base. Normal practice at Castle Air Force Base is to send seven airmen and two IPs with each train. These individuals conduct training at the host bases and maintain the simulator while it is away from the support base (currently, for a period of approximately one month per move). Between moves, personnel are assigned duties around the "static" simulators at Castle.

The utilization schedule for the mobile simulators is established by regulation (SAC Regulation 50-46, p. 21). The mobile simulators are required to be available for training 12 hours per day, and 6 days per week, if necessary to meet local training needs. The seventh day is normally set aside for maintenance. Units operating on a compressed schedule, however, "will have the simulator available up to 18 hours a day if required" with no day off for maintenance.

The host base Unit Chief of Training is responsible for scheduling all training requirements while the simulator is on station. Usually the

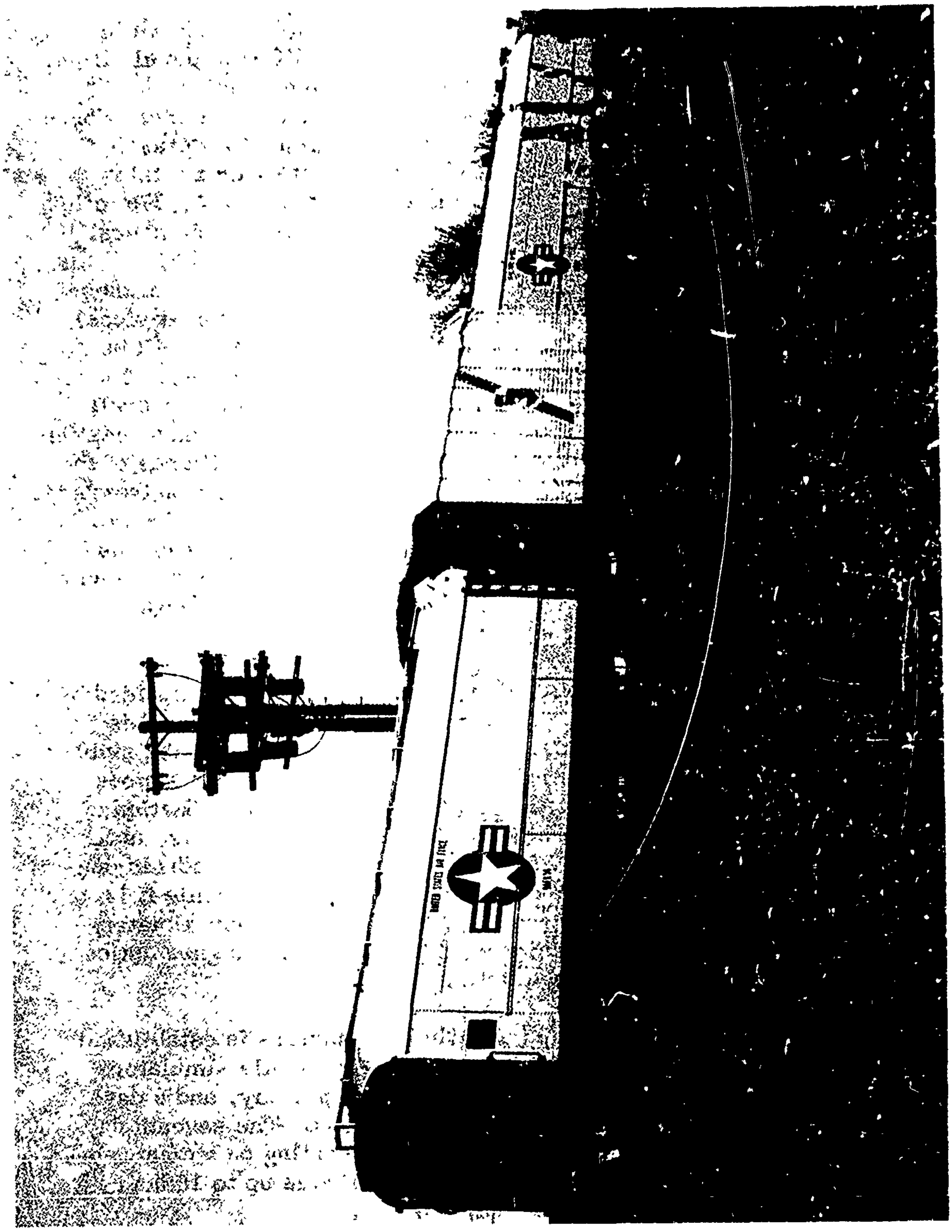

Figure 5. B-52 Mobile Flight Simulator

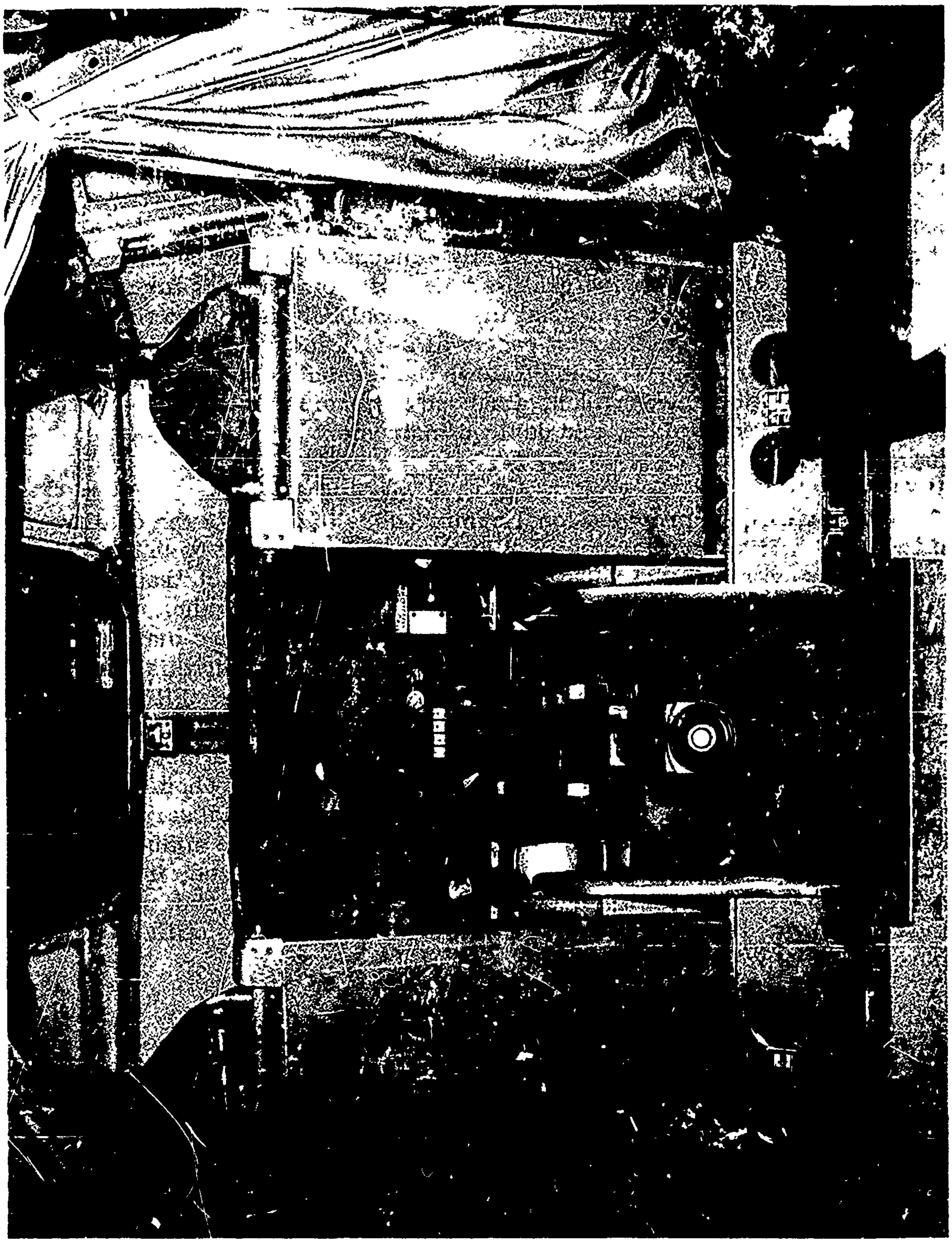

Figure 6. Cockpit Interior of KC-135 Mobile Simulator

simulator will be scheduled to impart the required SAC Manual 50-24 training. However, other types of training may also be given in the mobile simulators. These include transitioning to new models of the aircraft; in the case of the B-52, transitioning to new types of instruments installed in the aircraft, such as the Flight Director System now installed in approximately 50 percent of SAC's B-52s; copilot upgrading; and special courses to familiarize aircraft maintenance crews with engine or system operation and troubleshooting. Wherever possible, combat crews are scheduled to receive simulator training while on alert status. Training sessions are normally conducted by permanently assigned simulator IPs who are qualified aircraft commanders for the appropriate aircraft. If additional instructional help is needed to accomplish scheduled training, the host base will assign local pilots to temporary duty as simulator IPs. Training follows the lesson plans established for the type of missions being given, amended to consider local factors such as fuel loads, takeoff data, and desired instrument departures and letdowns.

Opportunity is provided local commanders to evaluate the quality of training their aircrews receive. Each six months, host base aircrew standardization personnel perform a sample mission in each trainer assigned to the base. The purpose of this mission is to evaluate the methods of instruction and course presentation and to insure that only current procedures are included in the curriculum. During this check, the training device is also evaluated for operational serviceability.

Following completion of a mobile simulator visit to a local unit, the Unit Chief of Training is required (within five days) to submit a report of accomplishments to the numbered Air Force headquarters. This identifies the type of simulator; the inclusive dates of simulator utilization; total time scheduled, in hours; total time utilized, in hours; and the number of no-show periods. Reasons for each no-show period must be provided and the difference between scheduled and utilized time must be explained as applicable.

SECTION III

DISCUSSION

The installation of an aircraft simulator facility currently costs in excess of one million dollars. To this basic figure must be added the cost of housing the facility and of providing trained operating and maintenance personnel. Thus, the total expenditure for acquiring a simulator training facility and operating it over a period of years will run many millions of dollars. With an investment of this magnitude, it is imperative that maximum training benefit be obtained. This disucssion focuses on current simulator utilization practices within the Air Force and, as warranted, presents recommendations which it is believed would increase training effectiveness. Finally, certain issues with respect to simulator use are described for which additional research is warranted in order to define optimum utilization procedures.

As particular topics regarding simulator utilization are covered, the discussion draws on three sources of information. These are:

1. Interview Data. Extensive interviews were held with Air Force personnel engaged in the day-to-day business of training pilots. Based on their extensive familiarity with aircraft simulators, these individuals have formed very definite opinions concerning the best manner in which to use these devices. While these opinions at times are at variance with the basic design capabilities of simulators and with current training technology, they are nonetheless given careful consideration and are weighted heavily in the discussion.

2. Air Force Documents. A considerable number of official documents concerning the structure of simulator programs and specific aspects of simulator use were provided by the various training units. These materials were studied in detail.

3. Training Research Information. In preparing the discussion section, it was discovered that a third source of information was required to satisfy the purposes of this survey. This source draws on data available in the technical literature regarding training research. This literature defines methods and techniques for optimizing training systems and for enhancing transfer of training from one set of tasks to a second set of tasks.

OBJECTIVES OF SIMULATOR TRAINING

The principal objective of Air Force flight simulator training programs is to develop proficiency in the procedural components of flying tasks. Both normal and emergency procedures are taught. However, the emphasis is on emergency procedures training. Currently, many simulator transition training programs consist of approximately 70 to 80 percent emergency procedures training. Cockpit familiarization accounts for a portion of the remaining content.

Less emphasis on emergency procedures training occurs when deficiencies in pilot background experience require use of the simulator for other purposes. For example, pilots transitioning to newer aircraft from older ones may require considerable training in the use of modern instruments. In qualification training programs for interceptor aircrews there is also less emphasis on emergency procedures training. These programs are oriented more toward providing practice in the normal procedures involved in the setup and use of airborne radar and in providing practice in flying various intercept profiles.

Normal procedures training includes training in the use of checklists for the aircraft, general instrument usage and interpretation of readings for specific purposes (e.g., instrument departures and letdowns), engine runup and shutdown procedures, arming and aiming procedures for tactical weapons, and training for flight tasks where responses must be chained, patterned, sequenced, or integrated into a whole. Generally, the extensiveness of normal procedures training is at the option of the local training unit to which the simulator has been assigned.

Few pilot training units (ATC excepted) attempt to teach "normal procedures" in the simulator in any concerted way. The chief objective of most transition programs concerns the recognition of emergency conditions and the initiation and execution of corrective actions for these conditions. Normal procedures training is often included only insofar as normal flight conditions consitute preconditions for the insertion of realistic malfunctions (emergencies) into the training problem(s).

At several of the units visited, IPs felt that additional simulator time could be fruitfully devoted to normal procedures training. This would better prepare the pilot to fly the aircraft under normal flying conditions. At one large training unit engaged in transitioning pilots into multiengine cargo aircraft, more than 50 percent of the students of four recent graduating classes indicated (on their critiques of the simulator course) that too many emergencies were presented during simulator

training. This was said, by the students and some IPs, to detract from the realism of simulator training since flying cannot be characterized as consisting of continuous problem solving situations.

To overcome what is an apparent lack of preparation in the simulator for normal flying tasks, one small MAC training unit has added an extra mission to its simulator curriculum (over the number required by MAC Regulation 50-8). This allows additional training on normal procedures for the aircraft. Training personnel believe that this additional mission helps the student to transition into the aircraft.

At another MAC training unit, many pilots in the transition program are unfamiliar with the modern instrumentation (e.g., vertical tapes, Flight Director System) in the new aircraft. Recognizing that a severe load was being placed on the student (and the training organization) by the requirement to learn (and teach) both instruments and emergency procedures at the same time, this unit has recently revised its simulator syllabus. Currently, pilots receive two lessons on basic instruments before being given emergency procedures training. This revision constitutes an implied recognition that the simulator has value beyond the training of emergency procedures, and that when necessary, the simulator can be, and is, used for additional training purposes.

Throughout all commands, IPs noted time limitations as the principal reason why the simulator was not used to provide more training. Representative comments were:

ATC: The simulator is used for only about 1/3 of what it could be used for. More training time would be beneficial.

More time could be used on advanced instrument type missions (e.g., VOR).

TAC: One item in the simulator doesn't work, but it is probably not necessary because there is not sufficient time to use it anyway.

The simulator could be used for more than emergencies if we had more time. At present, however, we're too busy doing other things.

More training could be done and more value obtained if more time were added to the syllabus.

SAC: We are confined to a specific syllabus which fills up the time available. We could do more if we had more time.

The simulator is good for instrument training but there is insufficient time for it.

MAC: We do not have enough time to accomplish in the simulator what should be taught because of the requirement to teach instruments.

ADC: The heading and attitude indicator in the simulator is not used because there is no time or requirement for it.

Although comments such as the above were fairly common, they do not mean that IPs want more time added to the simulator program. Rather, they constitute recognition that the simulator has inherent capabilities that could be used to provide more training than currently given if it were necessary to do so. However, more time would be required to accomplish the additional training requirements and still teach emergencies. In actuality, very few IPs would be in favor of lengthening simulator training time, mostly because of their preference for training in the aircraft.

Summary

Current training objectives for the simulator concern the development of proficiency in procedural tasks. Emergency procedures training receives the greatest emphasis in the simulator. Normal procedures training, i.e., training of sequential performance tasks and especially training of the procedural components of flying tasks (e.g., maneuvers) are less emphasized. IPs recognize that the simulator has greater inherent training value than its current usage indicates. However, there is no requirement to use it for more training than already incorporated into existing programs. There is also insufficient time to conduct more training. Given additional training needs, local training units frequently do expand training objectives and simulator usage to accomplish these needs. Generally, this is within current time allotments established for simulator training.

Recommendations and Research Issues

Insofar as simulator training objectives are concerned, there seems to be little question in the minds of IPs that these devices are satisfying

training requirements. The devices "are doing what we want them to do." In a more objective vein, however, the central question exists of whether additional training objectives should be established for the simulator. The answer to this question is difficult because use of the simulator is largely delegated to the local training unit to determine how it can best be used, within the general guidelines and time for use established by Air Force or Command, to meet local training needs.

In the interest of training efficiency and to obtain more value from flight simulators, it is clear that effort could be profitably expended to delineate those training objectives that are realistic for the simulator. As currently practiced within the Air Force, the establishment of objectives for the simulator often is more out of consideration for what cannot be taught in the aircraft (either for safety reasons or for time limitations) than for what could be taught in the simulator. A more positive approach to the establishment of simulator training objectives is warranted.

This approach should consider what objectives could or should be established for the simulator in order efficiently to achieve a given overall pilot end product through judicious use of both simulator and aircraft. It is clear that the development of proficiency on emergencies would remain one of these objectives. However, extension of objectives to include more deliberate emphasis on items such as those delineated on page 12 of Section II also appears fruitful.

Within the structure of current simulator training programs, research is needed to establish the degree to which current training objectives could be achieved by devices less complex and costly than full mission simulators. The capabilities required of these devices (e.g., motion systems, visual attachments, degree of system simulation, etc.) also would require determination.

FIDELITY OF SIMULATION CONSIDERATIONS

It is apparent that the objectives of simulator training programs do not coincide with the opinions of some experts as to what could be taught in the simulator. In theory, in addition to being useful for teaching procedures, modern flight simulators are capable of providing full mission training and should also be useful for teaching the handling qualities and response characteristics of the aircraft (see, for example, Newell, 1959). In actual fact, the simulator is rarely used for these purposes.

IPs give a number of reasons for limiting simulator usage to the training of flight procedures. Some of these have been discussed previously. Others stem from inexact or incomplete simulation of aspects of the flying job. Although this survey was not directly concerned with fidelity of simulation, it was inevitable that such considerations would arise. It appears that these factors affect the IP's perception of value of the simulator and condition his attitudes toward the device. Consequently, they affect his acceptance and use of it in the pilot training process. Thus, some aspects of "fidelity" must be considered in the interest of obtaining maximum training value from flight simulators

Frequent and vociferous complaints were made by IPs about the handling qualities of the simulator. Most IPs asserted that it is virtually impossible to get any appreciation for the handling characteristics of the aircraft from the simulator. Lack of correspondence of control forces between the simulator and the aircraft was the principal reason cited for this. Simulator controls were said to be hypersensitive, pitch control could not be maintained in many of the simulators, and stick and rudder forces were not in correspondence. Since the simulator "does not fly like the aircraft," IPs as a group, do not attempt to teach handling characteristics in a deliberate way. Other complaints in this area concerned different nose attitudes and airspeeds on takeoff or landing, and different power to airspeed relationships. A complaint made of all simulators, regardless of device age, referred to the difficulty, and in some cases, sheer inability, to trim the simulator. This aspect, perhaps, more than any other, is blamed for limiting the simulator's usefulness to procedures training.

At a number of training units, the simulator and flying phases of training are viewed as essentially involving the teaching of different types of things. Simulator training is confined principally to emergency procedures training. In the flying phase, the student learns the feel and response of the aircraft and the techniques involved in instrument flying plus takeoff and landing. Because of control problems, simulator training periods are characterized as requiring constant attention, alertness, much concentration, and work by the student pilot to control the device. Momentary distractions are said to be likely to result in loss of control of the simulator. Most training units, however, do require that the student pilot fly the simulator during training, but do not emphasize handling. At certain other units, the practice is followed of using the autopilot for most of the simulator flying, ostensibly to permit the pilot to concentrate on learning operational procedures free from control distractions.

Another fidelity consideration frequently mentioned by IPs referred to incomplete simulation of the airborne environment. Since present simulators are, in essence, IFR trainers, many IPs cited the inability of the devices to provide training on flight items requiring visual references (e.g., landings, takeoffs, refueling, circling approaches, etc.) as limiting their usefulness. While generally this was directed only at certain segments of flight, tactical reconnaissance and fighter units cited it as a reason for the inability to provide mission training in the simulator. For these units, the bulk of mission flying occurs within a VFR context. It must be noted, however, that lack of visual cues in the simulator was cited more as a training limitation of the simulator rather than as an area for improvement of it. While many IPs noted that a visual attachment might benefit training, few were convinced that it would because of the belief that these things are better taught in the aircraft. In most cases, these individuals had not had previous experience with visual attachments, hence could not really appraise their worth. The few who had, however, mostly depreciated them as providing unrealistic presentations.

Simulator Design versus Training Objectives

To obtain information on the relationship between simulator design and its use for training, IPs were asked, "Is the simulator used in the training of tasks for which it was designed?" Many IPs asserted that it was, but added that this was because it was designed for teaching emergency procedures. Other IPs, however, recognized that the simulator was also "obviously intended to be used to teach an introduction to actual flying and handling characteristics of the aircraft," but that it was deficient for this purpose. Hence, an element of uncertainty appears to exist concerning what the simulator should be able to accomplish.

In one case, a complaint was made that the simulator was too complex (designed for full mission training) for the job it is supposed to do (teach procedures). Consequently, portions of this modern simulator, including the landmass simulation capability, were not used in training because of the lack of need for this capability in the current syllabus. Similar statements were made in regard to a modern digital simulator for a large transport aircraft. IPs noted that this simulator could do more than it was needed to do and also that certain features of the device were not needed. In both instances, several training personnel noted that these devices should be designed more for meeting the specific needs of a local training unit.

Summary

It is apparent that there is a disparity between the design of a simulator and its use in training. Reasons why the simulator is not used for more than procedures training are complex. Most IPs feel that the correspondence of the simulator to the aircraft is not sufficiently close for teaching items useful for actual control of the aircraft in flight, i.e., aircraft handling. Visual flight cues are also lacking in the simulator and training for VFR flight tasks/missions cannot be given. Many IPs believe that the simulator is designed for emergency procedures training and therefore limit its use to this.

Recommendations and Research Issues

IPs perceive the lack of correspondence of the dynamic qualities of the simulator to the aircraft as limiting the training potential of the simulator. Therefore, concerted attempts to teach certain aspects of flying tasks are not made. This conclusion of noncorrespondence between the two sets of tasks implies a variety of research needs within the general area of fidelity of simulation. However, this survey was not concerned with this aspect of the training problem; hence, specific research needs with implications for simulator design rather than training efficiency will not be delineated here. Research does appear indicated, however to determine the extent to which attitudes toward deficiencies in fidelity affect use of the simulator and, therefore, its ultimate value for training.

Noncorrespondence of control feel does affect the IP's perception of value of the simulator. But it is not clear that this factor does, in fact, limit the training value of the simulator. An experimental study conducted several years ago (Matheny, Williams, Dougherty, & Hasler, 1953) investigated just this topic. This study found that differential amounts of control stick pressure in the simulator (one group learned maneuvers in the simulator with minimum control pressures and another learned them with pressures roughly equivalent to the aircraft) did not differentially or adversely affect subjects' subsequent learning of climb and glide maneuvers in a T-6 aircraft. Further studies in this area clearly are needed to clarify the relationship of control factors to ultimate simulator value.

CONTENT OF TRAINING

Section II describes the mechanics of simulator syllabus development and change. To summarize, the content of training is usually

developed by local unit training personnel. Although certain guidelines are provided by higher command and Air Force levels, determination of what to include in specific terms is largely the province of the local unit. This is based on expert judgment as to what is needed to achieve simulator training objectives.

Few specific comments were made by IPs concerning simulator training content. In view of the fact that content of training programs is developed to achieve specific training objectives, this is not surprising. Current objectives are limited; hence, content is also limited to reflect these objectives. A number of IPs did, however, comment that, often, too many emergencies were contained in the syllabus. This has implications for conducting training and is discussed in the next subsection.

Recommendations and Research Issues

Current simulator training objectives are reflected in the content of training. In the interest of extending these objectives, and of improving the efficiency of current training systems, certain research needs are apparent.

Analytic effort is indicated to identify tasks to be trained and the degree of proficiency required. An analysis and realistic appraisal of the simulator's capabilities for providing training in these tasks also is required. On the basis of these analyses, certain tasks can be identified for simulator training and others for aircraft training. It is likely that such analyses would not result in a clear-cut division of tasks to be trained in one device versus the other but instead would identify tasks to receive differential emphases in each portion of training.

Additional effort beyond simple identification of what to train in the simulator would also be required in order to structure an effective simulator syllabus. To illustrate: given the determination that emergencies, for example, are better trained in the simulator than in the aircraft, further effort is required to define content items such as, what kinds of emergencies, and how many, should be included in the syllabus. In this context, it is not likely that all of the emergencies listed in Technical Orders for the aircraft need be trained. Certain groupings could be made. Factors such as probability of occurrence and consequences should also be considered in developing the syllabus. For example, including certain malfunctions in the syllabus whose consequences in the real world are invariably catastrophic, and for which there is no recovery procedure, seems fruitless in terms of efficient use of training time and transfer of training. Similar considerations

should also be applied to develop specific content for other simulator training items.

CONDUCT OF TRAINING

Two topics are included here: training schedules and training practices. The first is concerned with the placement of simulator training within the overall training program. The second is concerned with the way in which simulator training is conducted.

Training Schedules

A major consideration in the area of training conduct is the temporal relationship between simulator periods and aircraft periods. As noted in Section II, a variety of schedules are followed. At some units, all simulator training is given in a block before the flying phase. At other units, flying lessons and simulator lessons are interspersed. In some cases, simulator training is given as part of the ground school program. In others, it is given as a separate phase within the overall program, and in still others, as a part of the flying training program.

The block sequence of simulator training and schemes which intersperse aircraft and flying lessons are defended by their proponents on the same basis, i.e., professional judgment that this is an optimum arrangement for their given situation. The block sequence is additionally justified on the grounds that once the simulator training is completed, the student is prepared to cope with any (emergency) contingency that may arise in the aircraft.

At units which intersperse lessons, the usual case is that the simulator lessons are given in advance of specific aircraft lessons. Thus, they provide the trainee familiarization on aspects of flight tasks before he encounters them in the aircraft. However, simulator lessons are rarely given in immediate preparation for the next day's flight. Usually these lessons are given out of consideration for scheduling convenience rather than for potential training efficiency. Simulated radar intercept lessons, for example, are usually given by interceptor aircrew training units while the trainee is flying transition lessons in the aircraft. Thus, these may occur a number of days in advance of their appearance in the flight syllabus. Also, the general practice is to complete the simulator lessons as soon as possible after flying training begins.

At one training unit where airborne radar is heavily employed in the mission context, IPs noted that the practice of preceding each aircraft flight with an identical simulator mission might significantly improve the training given for airborne intercept. This would also help in preparing for a particular flight and would mean that the IP would not have to teach certain aspects during the briefing portion of the flight. Time considerations, however, have precluded the adoption of this practice.

Related to the problem of scheduling simulator lessons in relation to flying lessons is the problem of placement of simulator training within the total training program. At some units, simulator training begins while the student is learning aircraft engineering and may be used for demonstration and practical application of knowledge gained in the classroom during earlier sessions. In other cases, simulator training is simply a phase within the ground school program, usually occurring near the end. In one case, the simulator program is a separate phase of training, occurring between engineering and flying training. Other schemes are followed by other units. Although the relationship of simulator training to the overall program was not specifically mentioned by IPs, it is reasonable that different arrangements of these components might be more efficient than others.

Training Practices

Within the confines of the established course syllabus, IPs are given wide latitude to conduct simulator training in ways deemed effective by them. Thus, at this level, there are virtually as many different training practices within the Air Force as there are IPs. For this reason, a detailed discussion of simulator training at this level is not attempted. However, a number of items within the more general context of training practices require comment.

It was noted at several units that the need to present a fixed number of emergencies within the timeframe established for simulator training often resulted in their being presented too close together. Consequently, the student was frequently still working on the solution of one problem when a new one was presented. It was also noted that malfunctions were sometimes introduced too soon in training, at a time when the student was not sufficiently familiar with the normal operating characteristics of the aircraft.

Several IPs noted that there was often little opportunity to give repeated practice on particular items of simulator training. The content

of most simulator courses is extensive. Hence, to accomplish all of the required training within a set time period, the student must frequently "speed through checklists" simply to cover basic content. This obviously precludes repeated practice, which is one of the principal advantages of the simulator. One IP noted that, "More emphasis should be placed on the repetition of emergencies and these should be given until you are sure that the man has it." Similarly, two students (at a different training site) felt that insufficient time was allowed in the simulator for the pilot to understand and absorb solutions to the emergencies presented. The implications for retention are apparent.

In training copilots for multiengine aircraft, standard procedure involves taking two trainees through the program as a team.[6] In the simulator, each trainee receives half of the allotted time in the copilot's seat and the other half in the pilot's seat. IPs point out that this is the only place where copilot training is given, since the trainee flies in the pilot seat during aircraft training. (The IP flies as copilot in the aircraft while the second student observes from between the seats.) Consequently, some feel that more emphasis should be placed in the simulator on these copilot duties. In at least one instance, IPs noted that certain training problems were also presented by this practice. Since the course is structured as an aircraft commander/copilot course, the degree of guidance that the copilot trainee would normally receive from the aircraft commander is not present.

In several multiengine aircraft training programs, flight engineers are also trained simultaneously with the pilot trainees. This practice may affect the training given the pilots insofar as the quality with which the flight engineer performs his tasks is concerned.

Most simulator training units use enlisted men to support training sessions by serving as controllers and voice operators. Belief in their value for this purpose is less than wholehearted, however. Several IPs noted that the realism of training is often destroyed by the less-than-adequate preparation for these duties given the individuals who perform them. Based on the belief that enlisted men are not qualified to train pilots in any way, two training units have now abandoned this as a normal practice. IPs themselves now simulate these functions.

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[6] While the team concept is currently followed in training, individuals are no longer reassigned as crews.

Summary

Simulator training within the Air Force is conducted under highly variable circumstances. This applies both to inter- and intratraining unit practices. Some units give simulator training in a block before airtime; others intersperse the two kinds of lessons. There also is inconsistency in the position which simulator training occupies within the overall training program. The freedom permitted IPs to conduct training results in many different training practices. Often, because of the necessity for training a large number of items, only very limited opportunity is provided for repetition of materials. Certain training problems also arise from simultaneous crew training which may affect simulator training value.

Recommendation and Research Issues

It is apparent that conflicting notions exist concerning when to use the simulator for training and how best to use it for greatest training efficiency and transfer of training value. Research is needed within this area to determine the value of block training versus training schemes which intersperse aircraft and simulator lessons. In this regard, the value of simply interspersing flying lessons with simulator lessons should be examined in relation to an alternated sequence which employs the simulator, for example, as preparation for the next day's aircraft lesson.

Effort also is needed to determine where, and how much, simulator training should be used in relation to other portions of the training program. Use of the simulator to demonstrate systems operation and to reinforce materials learned in aircraft engineering courses appears to be a desirable application of the device independently of its use in direct preparation for flying lessons.

It appears that current simulator training programs are not structured to capitalize on one of the more apparent advantages of the simulator, which is to permit repeated practice and thus overlearning on certain critical components of flight tasks. An assessment is required to determine whether training programs should be modified to take greater advantage of this capability.

Special training problems arise when more than one trainee is involved in the training program insofar as the actions of one affect the problems presented to the other(s). Consideration should be given to effecting schemes for dealing with these problems. This should

include an assessment of the merits of giving independent training to each crewmember in order to bring him to some defined level of proficiency before giving simultaneous training.

Several IPs noted that the timing of events in the simulator does not match that for the aircraft. This can be a result of training practices with the simulator or may be inherent to its design. Because of time pressures for the many items that must be accomplished in the simulator program, there is a set time to do things. Consequently, malfunction solution may not be accomplished in real time for the aircraft because the student must "speed through checklists" in the simulator. Concerning simulator design, some IPs noted that events happen in the simulator within a timeframe different from that in the aircraft. For example, "climb to altitude" may occur in the simulator in half the time required in the aircraft. Airspeed power relationships may differ between simulator and aircraft, and auxiliary systems such as TACAN may "click off miles" at a rate different from the aircraft. The implication is that correct pacing and timing (of maneuvers, for example) cannot be learned in the simulator. IPs may also blame this type of deficiency (particularly for high-performance aircraft) for limiting the trainer to a procedural role. This notion of nondevelopment of events in real time is a compelling one and should be thoroughly explored by research for its implications for general transfer of training situations.

Research is also needed to determine optimum length and content of individual simulator lessons and the overall simulator training program. For both training efficiency and enhancement of training transfer, the optimum arrangement of training units (e.g., lessons, elements within lessons) to each other should also be investigated. For example, what should be the order and progression of training units both temporally and with respect to difficulty?

In addition to analytical research, validation studies in the above areas are indicated. So too are studies to improve training efficiency through the use of programmed instruction techniques, as it is apparent that many aircraft "procedures" could be taught in this way.

PROFICIENCY ASSESSMENT PRACTICES

Proficiency assessment in the simulator is, in general, a very loose and informal process. In the usual case, the trainee is required only to demonstrate satisfactory performance to his IP. IP judgment serves as the criterion for determining when this "satisfactory" level

of proficiency has been achieved. Frequently, the IP may determine that student proficiency is less than satisfactory. In these cases, provision may be made for giving additional simulator time to deficient students. However, this is rarely done. Usually the areas in which the student is weak in the simulator are "flagged" for emphasis during the flying phase. Because of time pressures, assessment of student progress through the syllabus is the primary interest as opposed to strict grading.

Few IPs commented specifically on proficiency assessment practices. One, however, noted that the intent is to help the pilot and not to grade him. Thus, proficiency records are geared to "complete." Another noted that IPs are not interested in "busting egos" in the simulator. Apparently, there is a real lack of interest in rigid proficiency assessment (ATC excepted). Accordingly, little use is made in transition training programs of features of the simulator provided for this purpose (e.g., groundtrack recorder, approach plotter, etc.).

Recommendations and Research Issues

Currently, assessment of student proficiency on simulator tasks in any formal way is of only limited interest to pilot training personnel. Defined standards of performance are rarely employed for grading purposes. Lacking these, it appears that pilots leave the simulator at highly disparate proficiency levels and having received differential benefit from it. Some effort is indicated to determine the desirability of adding more formal proficiency assessment practices to current simulator programs.

Since proficiency assessment is the key to understanding, and thus enhancing, the value of any training system, research in this area should be considered mandatory if training objectives are to be extended for flight simulators. Considerable effort will be required to define the components of proficient behavior and optimum measurement methods, techniques, and formats for assessing pilots' levels of proficiency at given points in time.

SIMULATOR PROGRAM SUPPORT

During the survey, a number of considerations arose which are tangential to the main issue of training use of simulators but which nevertheless have implications for the efficiency and value of these devices in the pilot training process. These considerations relate to the maintenance and support provisions for these devices. Several of these factors are discussed below.

Organization and Function of Simulator Sections

Air Force Manual 50-16 (Employment of Aircrew Trainers) provides guidelines for establishing a training organization for effective use of flight simulators. With the exception of the SAC CCTS, however, the structure and function of simulator sections within the Air Force do not clearly or consistently reflect application of these guidelines. Most simulator sections are organized strictly for housekeeping purposes. They operate and maintain the training devices assigned at a particular location and otherwise make the devices available to their IP users when their use is required. Direct involvement in the training process is rare.

At the SAC CCTS, a single OIC is responsible for both the maintenance and training use of the simulators. Also, at one MAC unit, a single OIC is responsible for simulator scheduling, maintenance, and training. In both instances, permanent IPs are assigned to simulator instructor duty. They, therefore, have had relatively extensive experience with the devices, are thoroughly familiar with their operating characteristics, and thus are better prepared to recognize, and explain to students, differences between simulator and aircraft performance characteristics. At both units, practices such as these were seen as highly desirable from the standpoint of resolution of traditional coordination problems and training efficiency.

ATC synthetic trainer sections currently maintain the assigned trainers and provide instructor personnel. Several individuals commented that from the standpoint of maintenance, the practice of having qualified technicians instructing on the trainers probably tended to reduce overall maintenance needs. (The concept of the enlisted instructor is discussed on page 48.

As noted in Section II, simulator sections are sometimes not within the same chain of command as the operational units whose training needs they serve. However, IPs interviewed at these units did not feel that this situation gives rise to serious difficulties in obtaining use of the simulator for training. Maintenance personnel, on the other hand, did sometimes feel that their units of assignment were not as sensitive to support needs as the training organization would be.

Scheduling/Availability for Training

While one might expect that simulator training periods would be scheduled by the section in physical possession of the devices and thus

best apprised of their operating status, this is not the usual case. Simulator training schedules are made up with regard to an overall training schedule by other organizational sections. The simulator section usually has a coordinative input to this process, but is nevertheless subservient to established schedules. The chief responsiblity of the simulator section in this regard is to insure that the simulator(s) and necessary support personnel are available for training when required.

Depending on factors such as the number of simulators available for training use, ready availability of spare parts, competency and number of assigned maintenance personnel, time available to perform maintenance, etc., the schedule requirement may mean that the simulator will be used for training with less than its full capability. At one unit, in fact, a simulator which was technically unavailable for training because extensive modifications were being made to it, was still being used since there was no way to accomplish the required number of hours of simulator time without using it. While in most cases, the situation is not this extreme, it is apparent that the requirement to meet schedules, insofar as it does not consider the operating condition of the simulator at a given time, does have implications for the training that can be given and its value. The current training load has heavily taxed available training and support facilities. Despite the fact that simulators are on a 24-hour maintenance schedule at many units, all necessary maintenance (compounded by parts procurement) may simply not be accomplishable prior to each scheduled training period.

Apparently, there is also an interaction between maintenance practices and training practices. Several IPs noted that there is a tendency to maintain only those parts of the simulator that are used in training. Maintenance of portions not frequently used tends to fall off. It appears that, in at least some instances, a vicious circle is created by what is ostensibly a necessary expedient within available support resources. Training practices determine maintenance practices. What is used is maintained. What is not maintained is not used.

Logistics

Almost all of the instructor pilots interviewed and a variety of other training and maintenance personnel cited logistics problems as deterrents to simulator training value. This included both modifications to the simulator and the obtaining of spare parts for day-to-day operation. Virtually all of the simulators in the study were labeled as not compatible with the current aircraft configuration owing to lack of accomplishment of modifications. A significant exception was the C-141 Flight Simulator which has a continuous modification program.

IPs delineated numerous instances of noncorrespondence between aircraft and simulator due to failure to modify the simulator. Some examples were that the simulator had: no TACAN, no ILS, old VOR, different type of ejection seats, old starter panels, different tactics package, etc.

Although most simulator sections have received authorization to effect modifications that are within their immediate unit's capabilitites, many of the required modifications are not. Consequently, these units must await action and funding by higher headquarters. This usually involves lengthy delays. Estimates of time required to obtain modifications ranged from a low of nine months behind the aircraft to a "typical" lag of two to three years.

In addition to modification problems, the procurement of spare parts for day-to-day operation has continued to be a problem at several of the units visited. Simulators, according to maintenance personnel, are placed at the bottom of the supply channel in relation to support provisions for the aircraft. Consequently, it is often necessary to run training problems in the simulator (already unmodified) without full capability. Either a component does not operate or it is simply missing. One practice employed, in the case of two-pilot aircraft, is to switch instruments from the copilot's to the pilot's side in order to conduct required training.

While a considerable segment of the parts problem has been alleviated by special provisioning for units heavily engaged in training, and by granting local purchase options, other units either do not have special provisioning or needed items are not available in the local area. Consequently, IPs must conduct training in the face of what they have termed "minor irritants." Many have accepted these as inherent to simulators in general and have learned to "live with them."

Although the evidence is limited that deficiencies arising from maintenance policies and support practices directly affect the training value of the simulator in terms of the goals established for simulator training (i.e., emergency procedures), it is clear that they do affect the IP's perceptions of what the simulator can do and his acceptance of it in the pilot training process.

Utilization Reporting

It appears that a tendency exists to evaluate simulator sections in terms of their ability to meet the established training schedules.

Effectiveness of the simulator is often reported in terms of the percentage of scheduled requirements met. The nonaccomplishment of scheduled hours usually requires justification to higher headquarters. Within MAC, overaccomplishment also requires justification.

Examination of the many utilization reports obtained from headquarters and field units show that the simulator is rarely unavailable for training for maintenance reasons. Exceptions occur if simulator power or air-conditioning are out. Also, loss of a large portion of the computer (e.g., core memory) may preclude its use. The usual case is that when relatively "small" portions of the simulator are inoperative, it is still considered available for training. To illustrate, one maintenance supervisor related that loss of the TACAN unit, for example, would be reported to the squadron scheduled to use the simulator for training. The squadron would then decide if they wished to use the simulator without this capability. When the squadron elects not to use the simulator in such instances, the time allotted is recorded as a cancellation of training requirements, other considerations notwithstanding. It is not considered as a loss of training time related to maintenance.

For reasons such as the above and for the additional reasons cited below, no attempt was made to order or anlayze the data contained on the utilization reports. Lacking definite instructions regarding the treatment of various kinds of time, reporting units constitute and report training hours differently from others. Also, these units report maintenance technician training time, pilot training time, and other types of training (e.g., flight engineers) as a lump sum figure. Thus, it is not possible to determine from these reports how many training hours are devoted solely to pilot training or what the quality, in terms of true simulator readiness, of this training is.

MAC training units forecast anticipated simulator training requirements (in hours) on a quarterly basis. Thereafter, each monthly utilization report submitted must consider the forecast to the extent that justification to command is required whenever the training time actually used differs from the forecast by more than $\pm$ 5 percent. While it must be assumed that MAC does not intend to limit the use of the simulator for legitimate training purposes, at least one unit has interpreted this requirement as a limitation on its flexibility to give additional simulator time to pilots where it is deemed desirable to do so. This unit often has unanticipated requirements which cannot be adequately forecast. Therefore, it is required to submit frequent justification for overaccomplishment of schedules.

In all, it is difficult to perceive clearly the value of utilization reporting as it is currently practiced within the Air Force and as it relates to pilot training. The meaning of the data contained on these reports is, at best, ambiguous. While they do reflect that the units assigned simulators are using them for training, they apparently serve little useful purpose beyond this. What kind of training is being given, the degree of operability of the device (assuming it to be greater than zero) is unknown, etc. However, the Air Force is currently revising the utilization reporting system. This revised reporting system will be contained in Air Force Manual 65-110. Details of the revised system were, however, unavailable for discussion in this report.

Summary

Simulator sections are not usually directly involved in the training use of these devices. The chief function of these units is to maintain the simulators and to insure that they are available for training in compliance with established training schedules. Sometimes, it may be necessary to conduct training with less than 100 percent operational capability in the simulator. While this may be due to limitations arising from maintenance practices, it is also sometimes due to logistics considerations. Also, there is an apparent interplay between maintenance practices and training practices. Utilization reporting as it is currently practiced provides relatively little useful information for improving the training efficiency of the simulator program.

Recommendations and Research Issues

It is apparent that a number of support factors can affect the efficiency with which simulator training can be conducted. Extension of training objectives for the simulator might well require a different type of simulator training organization with responsibilities and authority different from those which these sections now have. Research is indicated in this area to investigate organizational forms that would be most conducive to satisfying broadened objectives. While it appears that the simulator program could be conducted more efficiently within a centralized organization, work will be required to define its components and personnel assignments.

Within the simulator support area, research needs are less evident than in other areas. What is indicated is the need for a general tightening-up of support programs. This would eliminate what "problems" may exist in keeping simulators fully available for pilot training purposes.

SIMULATOR INSTRUCTORS

Instructor Pilots and enlisted personnel assigned instructional duty on synthetic training devices are discussed herein.

Instructor Pilots

While well prepared for his instructional role in the aircraft (see pp. 32-48), the principal simulator user, the IP, receives, in most instances, little more than a cursory familiarization with the simulator which is devoted principally to operation of the trouble console. He is usually not well acquainted with the operating characteristics and inherent capabilities and limitations of the device itself. A number of IPs attested to this and further noted that, due to the press of other duties, they did not have time to "learn" the simulator. Thus, they may frequently have insufficient knowledge of what actually can be taught and how best to teach it within the inherent limitations of the device.

In several instances, maintenance personnel implied that what is sometimes attributed by the IP to poor maintenance of the device is in reality a reflection of the fact that the IP does not know that the simulator is functioning correctly. It is clear that many IPs fully expect the simulator to "feel" and perform exactly like the aircraft. To the extent that it does not, it may be attributed to faulty maintenance procedures.

At those bases where IPs are assigned permanent simulator duty, it is apparent that a greater understanding of what the simulator can (and cannot) do exists. IPs at these units "work around" simulator deficiencies and have a greater acceptance of the devices. Thus, the problem of negative attitude toward the simulator is not readily apparent, since the simulator is not expected exactly to duplicate flight conditions.

A small number of IPs, especially within tactical units, expressed the opinion that simulator instruction and value of the device might be significantly improved by adopting some type of arrangement featuring permanent simulator instructors. Several schemes were mentioned. Suggestions ranged from assigning this function to carefully selected and well-trained enlisted men through use of IPs permanently assigned simulator instruction duty and combinations of these personnel. A few IPs also believed that employing professional civilian simulator instructors might be of value.

Enlisted Instructors

Air Training Command has recently authorized enlisted men to train student pilots on aircraft procedures and instrument flying techniques in the synthetic trainers for the T-37 and T-38 aircraft. During the survey, a number of these individuals, and also IPs who conduct in-the-air training, were interviewed. Several considerations arose concerning the adequacy of this instructional concept.

Enlisted trainer instructors currently receive formal training as maintenance technicians (Flight Simulator Specialist, AFSC 342x0). Upon assignment to a training unit, selected individuals are given OJT for synthetic trainer instructional duties. This is followed by a formal evaluation of their ability both to instruct and to fly the trainer before assignment to primary instructor duty.

A number of IPs called attention to the enlisted instructors' limited technical background, specifically, lack of pilot experience. A great deal of judgment must be exercised to assess pilots' performance in the trainer. Enlisted men lack the flying background which IPs believe is necessary for making these judgments. Enlisted men, it was said, tend to grade subjectively and tend to include the idiosyncracies of the training device in their evaluation. However, it is not clear to what extent these criticisms more properly apply to grading practices rather than to the instructors per se. It was noted, for example, that an individual student pilot may be doing well in the trainer before making a prominent deviation on a maneuver. Despite the fact that he may make an excellent recovery from the deviation, he may be graded as unsatisfactory on the lesson. But this is in keeping with established practice and is readily defensible.

For their part, enlisted instructors also feel that grading practices are not ideal. The requirement for grading on minute portions of maneuvers was seen as making each trainer lesson a check ride for the student. Thus, little opportunity is afforded for the instructor to use his judgment, and no consideration is given to individual student needs by the grading practices followed (these are described on pp. 24-25 above). Instructors feel that they have become examiners rather than instructors. Some expressed the opinion that grading should be eliminated altogether.

In addition to the above considerations, other factors conspire to affect the morale of enlisted instructors. Mentioned by these individuals were that there is currently no maximum tour of duty as an instructor, and there is no limitation on the number of hours per day, or days per week, that an individual may be required to instruct. Limits do exist for IPs, however. Given a choice, enlisted instructors, it appears,

would rather perform the maintenance duties for which they received formal training than instruct. At one unit, only one individual out of 19 surveyed, expressed a preference for instructional duty over maintenance. Other items noted were that instructors are not awarded an instructor AFSC, manning is not authorized for purposes of training individuals for instructor duty, and promotion potential is poor in this career field. Two maintenance supervisors also expressed the opinion that maintenance training need not be viewed as a necessary prerequisite for an individual to be a competent synthetic trainer instructor.

Several IPs and other individuals involved in the ATC Undergraduate Pilot Training Program expressed the opinion that the quality of the synthetic trainer program within ATC could be improved by a return to the use of IPs for trainer instruction. This they felt would result in an increased capability for assisting weak students and for better utilization of the trainer. It would also result in better cross benefits since IPs would insist on greater standardization.

Recently, one Tactical Air Command training unit conducted an experiment to determine if enlisted men could be used to conduct required simulator training. This attempt was made to relieve a shortage of qualified IPs. As preparation for it, detailed lesson plans were drawn up for use by enlisted personnel. An IP conducted the first simulator lesson and enlisted men conducted all subsequent lessons. Unfortunately, enlisted men were not able to explain the "whys" or consequences of various actions to the student pilot or otherwise to provide necessary detailed knowledge about the aircraft. Consequently, the attempt was abondoned and IPs resumed instructional duties.

Summary

IPs are, in general, not well prepared for simulator instructional duty insofar as understanding of the capabilities and limitations of the simulator are concerned. Enlisted instructors, on the other hand, understand the operation of the simulator, but are deficient in knowledge of the aircraft.

Recommendations and Research Issues

Insofar as present training objectives are concerned, it appears that meeting these objectives does not require more extensive preparation for instructional duties than currently given. However, achieving full value from simulators of a given design requires that instructors be thoroughly familiar with the capabilities and limitations of the device.

Thus, future programs should consider more adequate preparation along these lines. It also appears that a clear understanding by the IP of what the simulator can and cannot do would considerably change his expectations toward it and thus provide for its more realistic use in pilot training.

Considerable effort also is indicated to define more clearly the value of enlisted personnel to the pilot training process and how best to use them. In this regard, effort will be required to define the type and depth of training necessary for the role assigned them and to develop effective forms of supervision and quality control.

VALUE OF SIMULATOR TRAINING

What is the value of simulators in the pilot training process? Precise empirical data are not available to assist in answering this question. Consequently, an attempt was made to obtain some indication of their worth for pilot training from the IPs. Opinions were solicited regarding the usefulness of these devices and their training transfer value.

Overall Value

The consensus of IP opinion is that the simulator has value for training procedural components of normal flying tasks and for training emergency procedures. It has little or no value for teaching aircraft handling and response characteristics. Virtually all IPs praised it for the ability to create conditions that could not safely be created in the air and for the opportunity provided the student to become familiar with various emergency devices and backup systems that are not normally (or safely) used in the aircraft. Thus, training can be given which could not otherwise be accomplished. The value of this training is, however, difficult to assess in any immediate way. As a number of IPs noted, it is impossible to tell how many accidents were avoided because of something learned in the simulator.

In a number of instances, IPs noted that simulator use allows trainees "to avoid a waste of flying time." In this regard, procedures can be taught in the simulator and valuable flying time need not be expended for this purpose. Instead, flying time can be devoted to learning aircraft feel and handling characteristics which cannot be taught in the simulator. This dichotomy is in keeping with a prevailing view that simulator practice does not substitute for flying time.

In an attempt to delimit the perceived value of simulator training more precisely, IPs were queried regarding possible reductions of airtime accruing from simulator experience. Estimates ranged from 0 to 15 hours. Generally, IPs training pilots for high-performance jet aircraft did not attribute any airtime savings to the simulator, although some noted that the simulator speeds up the aircrew's ability to get the aircraft "cranked up and rolling." This is because student pilots go to the flightline already familiar with the location and function of cockpit components. At these units, the principal reason cited for the nonsavings of airtime was that pilots do not learn aircraft control or response characteristics in the simulator, and this is viewed as the critical item which effects airtime savings.

At stations training pilots for multiengine aircraft, IPs were more likely to feel that some airtime was saved through use of the simulator. It is clear, however, that the basis for their opinions regarding airtime savings resides principally in the simulator's capacity for teaching procedures. Given the requirement to teach procedures in the aircraft, as well as aircraft response and handling characteristics, more time would be required. While airtime reductions were credited to the simulator by IPs for these reasons, this was by no means a universally held opinion. Even at these bases, a number of IPs noted that the pilot "could probably be checked out in the aircraft in the same amount of time without the simulator." However, most also believed that he would be a less proficient and less dependable pilot.

At the SAC Combat Crew Training School, which is perhaps the best instance of a well-ordered simulator training program within the Air Force, IPs were unanimous in stating that the simulator does not save airtime, because the items taught in the simulator are not the same as those taught in the aircraft. The simulator is an emergency procedures trainer; hence, simulator and flying time cannot be compared.

In a further effort to ascertain the perceived value of the simulator in the pilot training process, IPs were also asked, "What do you estimate to be the percent of total training value that the simulator contributes to the pilot end product?" Answers to this question varied greatly, and the quantitative estimates obtained could not be used. It became obvious upon detailed examination of the data that IP estimates were based on different criteria and different conceptions of the "end product" pilot. Some IPs answered the question in terms of the amount (or number) of procedures taught. Thus, training value was set at 90 - 100 percent for procedures. Others answered in terms of their estimation of how much of the flying job consisted of procedures (50 percent), or in terms of how much

knowledge was imparted by the simulator versus academics (i.e., engineering) and flying. In some instances it was also obvious that estimates were based on the length of various phases of training rather than being an independent estimate of simulator value.

Nevertheless, all of the IPs in the study did believe that the simulator has training value. Often, this is only for the training of emergency procedures, and, in this regard, the simulator is viewed as a necessary evil. Even within units training for tactical fighter-type aircraft, some value was atributed to the simulator. A number of IPs expressed the belief, however, that training transfer value of the simulator was limited to only initial flights in the aircraft. This ties in with the widely held belief that the simulator has no value for an experienced pilot (defined by a few IPs as an individual having 50-100 hours in the aircraft).

Prediction Value for Aircraft Performance

On a logical basis, one might expect some degree of correspondence between simulator performance and aircraft performance. In an attempt to ascertain this, IPs were asked to comment on the extent to which simulator performance predicts subsequent aircraft performance. A range of opinions was given.

Many IPs felt that there was a one-to-one correspondence for what is taught in the simulator (mostly emergency procedures, and secondly, instrument procedures). A man proficient in procedures in the simulator will know them in the aircraft. For items involving control of the aircraft, prediction was generally asserted to be poor. While this was tied in with the noncorrespondence of control forces, it was also related to the need for the pilot to use visual cues in flying. Several IPs at one high-performance jet training site noted that simulator and aircraft performance are totally unlike because the autopilot does most of the flying in the simulator. Also, most of the flying task is visual.

A number of IPs (at different locations) noted that simulator performance often predicts only in one direction. While "good" performance in the simulator usually indicates good performance in the aircraft, poor simulator performance does not necessarily mean that the man will perform poorly in the aircraft. This was especially true for the older, more experienced pilots. These men often perform poorly in the simulator, according to IPs, but excellently in the aircraft.

As a general consensus, IPs felt that prediction of aircraft performance from simulator performance is a difficult undertaking. The

value of the simulator was often seen as more for diagnosis and assessment, i.e., as a device for checking on whether the student was "doing his homework" on procedures and for indicating to the IP where emphasis should be placed during the flying phase. As many IPs noted, the intent of the simulator training is to get procedures out of the way so that the man can concentrate on learning to fly the aircraft. In at least one unit, it is stressed to students that the simulator is "not a teaching aid for teaching flight maneuvers" but is rather one for teaching procedures. Consequently, prediction is limited by this disparity between the two sets of required performances.

Visual and Motion System Assessment

During the survey, attempts were also made to assess the training value and pilot acceptance of visual attachments to, and cockpit-motion capability in, simulators. At four different locations, simulators representing four different aircraft types have visual systems. At six locations, simulators for four different aircraft types have cockpit-motion capability. At all these locations IPs were queried on the value of these adjunctive capabilities.

Assessment of the training value of the visual attachments could not be made due to the fact that at all of the locations visited, these visual attachments were inoperative. Training personnel further noted that they had been inoperative for extended periods of time. These devices had extensive maintenance needs, and spare parts could not be obtained to keep them in an operating condition. Hence, their use has been abandoned.

Motion capability was, however, usable at all bases. At most units, the decision to include motion in the training problem is made by the individual IP conducting the training. At one location, however, the syllabus requires that motion be used on all training flights. IPs at this base stated that they use motion on each mission because the motion capability provides a more realistic simulation of flight. They noted, however, that while the pitch portion of the motion system was good, the roll portion was uncoordinated. Specifically, the simulator did not correct itself well from a bank. While instruments inform the pilot that he is flying straight and level, the simulator is tilted. At another location where the same aircraft simulator is used, training personnel believe that the motion capability, overall, is an excellent feature. (It was also noted here that the roll portion of the simulator was not coordinated.)

At a base training pilots for multiengine cargo aircraft, IPs noted that they rarely used the motion capability. One IP noted that it was poor and unrealistic and believed that using it in training would have harmful overall effects on the trainee. Another stated that the motion is actually a deterrent in training. A third noted that the motion is distracting, overresponsive, and subject to many mechanical malfunctions. This IP, however, did use motion capability for students who tended to overcontrol the simulator, and found it useful for this type of individual. Some IPs also felt that use of the motion system in training restricted their instructional efficiency. This was because IPs instruct in the simulator cockpit while standing. Here, the motion capability interferes with their freedom to move about in the cockpit.

Motion systems for high-performance tactical aircraft also are rarely used. At one location, IPs noted that the motion was unrealistic and that it interfered with instructional efficiency when the IP was standing next to, and pointing to, components within the cockpit. Other IPs at this site used the motion system only infrequently because of the limited pitch and bank capabilities ($\pm 6^{\circ}$) of the system. At another location, using the same aircraft simulator, it was noted that the motion is not often used because it is unnecessary for what it teaches and also because it tends to make the students nauseous.

Summary

IPs, as a group, recognize that the simulator has value for pilot training. However, most perceive this value as limited to the teaching of procedures, especially emergency procedures. Within the framework of current simulator usage, there is a division of opinion among IPs as to whether simulator practice does, or can, save subsequent airtime and why. Similarly, IPs do not agree on how well simulator performance predicts aircraft performance. Apparently, this is because a different set of tasks is taught in one than in the other. To date, visual attachments to flight simulators have contributed little to pilot training because of difficulties encountered in keeping these devices in an operating condition. Also, there is considerable disagreement regarding the value of motion capability in the simulator.

Recommendations and Research Issues

Determining the value of the flight simulator to the pilot training process is a matter of paramount importance. The need for validation studies to determine in more precise ways exactly what contribution the simulator does, or could, make to pilot training is apparent. Research

is also needed to determine if, and what, simulator cockpit motion capabilities are conducive to achieving desired levels of transfer of training in terms of established training objectives and broadened training objectives.

SECTION IV

SUMMARY AND RECOMMENDATIONS

The purpose of this study was to assemble into a single volume information that would be useful to the Air Force in improving current and future flight simulator training programs. To achieve this purpose, visits were made to a number of pilot training units within five major air commands. Pilot training personnel were interviewed concerning simulator usage and value, and written documentation was obtained describing simulator training programs. These data were used to describe the current status of synthetic training programs. They also served as a basis for a subsequent discussion of these programs and for identification of research issues for improving simulator utilization and value for training. The major findings of the survey concerning the current status of these programs are summarized briefly below. Recommendations for enhancing the value and efficiency of these devices, which were offered in the text, are also summarized.

CURRENT FLIGHT SIMULATOR USAGE

Currently, flight simulator programs have the following features:

1. Objectives. Simulator training programs as presently structured have the principal objective of developing pilot proficiency on the procedural components of flying tasks. Emergency procedures training receives the greatest emphasis in almost all simulator programs. Local training units may extend objectives to meet local training needs.

2. Content. Within general guidelines and time limits established by higher headquarters, local training units develop simulator course syllabi and lesson plans. This content is keyed to the established objectives.

3. Training Practices. Considerable variability exists in the manner in which the simulator is used for training. Individual units place simulator training at different points within the overall training program. For example, some units give simulator training in a block before flying training begins. Others intersperse simulator lessons and aircraft lessons but not for the same reasons. Instructor Pilots have a high degree of freedom in determining specific usage of the simulator for given students.

4. Proficiency Assessment. With the exception of ATC, proficiency assessment in the simulator is informal. Concern is more with progress through the syllabus than with attainment of specified levels of proficiency on given items. Instructor judgment serves as the principal criterion of proficiency.

5. Support Factors. Administration of simulator training programs occurs almost entirely at the local level. Command support chiefly consists of insuring the availability of adequate training facilities to the local unit. Generally, simulator sections are organized for housekeeping purposes and do not become directly involved in the training use of flight simulators. Certain problems still exist in obtaining spare parts and modifications for simulators. For example, in some cases modifications to update the simulator to the current aircraft configuration may lag as much as two to three years behind the aircraft.

6. Simulator Instructors. Selection, training, and quality control of IPs are oriented chiefly toward the aircraft and in only secondary ways for the simulator. Generally, only limited training on simulator characteristics and the training capabilities and limitations of these devices is given IPs.

RECOMMENDATIONS

Based on data obtained in interview sessions with IPs, training research information, and evaluations made by the authors of this report, the following recommendations are offered for improving the future simulator training facility.

1. Objectives. Objectives should be delineated for the simulator which are realistically capable of fulfillment. These should be established based on analytical effort directed toward determining what aspects of the total flying job could be trained in the simulator and out of consideration for what the simulator is needed to do. That is, is it best used as an adjunct to the pilot training process or should it be used as a direct link in this process?

2. Content. Analytical effort is also required to determine what tasks should be trained in the simulator and what degree of proficiency is required. Considerable effort will be required to structure the content in appropriate ways for achieving various subgoals and overall training objectives.

3. Conduct of Training. Validation studies should be conducted to evaluate the effectiveness of various alternative training methods and techniques for the conduct of training. This must include consideration for who will conduct the training, what materials and methods will be used, sequence of presentation of various topics, and other factors involved in establishing conditions under which training will be conducted.

4. Proficiency Assessment. Methods and formats should be developed for assessing student proficiency (progress) in the achievement of training subgoals and overall training objectives. These are necessary for determining the level (and kind) of learning which occurs in the simulator. Effort is also required to insure the reliability and validity of the measures taken.

5. Support Factors. Effort will be required for determining which organizational forms are most effective for welding the various components of the program into a cohesive and effective training organization. In this context, careful attention must be devoted to controlling the quality of device maintenance and also to insuring ready availability of spare parts and modification of the devices whenever the aircraft is modified.

6. Simulator Instructors. In the interest of obtaining full value from flight simulators, it is important that instructors understand what a simulator can and cannot do. For example, simulators should not be expected to fly like the aircraft for the simple reason that they are not airplanes. But this need not detract from achieving much value from simulators by capitalizing on their inherent capabilities. What is indicated is more extensive training for instructors on simulator capabilities.

APPENDIX

UNITS VISITED DURING THE STUDY

Visits were made to the installations listed below, on the dates indicated, to obtain information on simulator training practices and device utilization.

15 Sep 66- 6 Oct 66	Headquarters USAF, Pentagon Directorate of Operations, Air Defense Division Directorate of Personnel and Education, Flying Training Division Directorate of Operations, Special Training Equipment Division
11 Oct 66	Headquarters Tactical Air Command Simulators and Facilities Branch Langley Air Force Base, Virginia
17-18 Oct 66	Tactical Air Command 4448th Combat Crew Training School Sewart Air Force Base, Tennessee
26-27 Oct 66	Tactical Air Command 363d Tactical Reconnaissance Wing Shaw Air Force Base, South Carolina
	Tactical Air Command 4414th, 4415th, and 4416th Combat Crew Training Schools Shaw Air Force Base, South Carolina
31 Oct 66	Headquarters Military Airlift Command Scott Air Force Base, Illinois
1 Nov 66	Headquarters Strategic Air Command Offutt Air Force Base, Nebraska

2 Nov 66	Headquarters Air Defense Command Ent Air Force Base, Colorado
7-8 Nov 66	Air Training Command 3525th & 3526th Pilot Training Squadrons Williams Air Force Base, Arizona
7-8 Nov 66	Military Airlift Command 443d Military Airlift Wing Tinker Air Force Base, Oklahoma
8 Nov 66	Federal Aviation Agency FAA Academy Oklahoma City, Oklahoma
9-10 Nov 66	Air Defense Command 4756th Combat Crew Training School Tyndall Air Force Base, Florida
9-11 Nov 66	Tactical Air Command 4453d Combat Crew Training Wing Davis-Monthan Air Force Base, Arizona
5-6 Dec 66	Tactical Air Command 479th Tactical Fighter Wing George Air Force Base, California
7-9 Dec 66	Strategic Air Command 93d Bomb Wing Combat Crew Training School Castle Air Force Base, California
13 Dec 66	Headquarters Air Training Command Pilot Training Directorate and Command Studies Division Randolph Air Force Base, Texas
14 Dec 66	Air Training Command 3510th Flying Training Wing Randolph Air Force Base, Texas
20-21 Dec 66	Military Airlift Command 436th Military Airlift Wing Dover Air Force Base, Delaware

PHASE I

PILOT SIMULATOR MISSION #2

EMERGENCY PROCEDURES

1. Briefing. Emphasis will be placed on action to be taken when malfunctions occur.

2. Procedures. Accomplish the following:

a. Engine start malfunctions.

b. Takeoff malfunctions and aborts.

c. Maximum power climb.

d. Electrical, fuel and oil system malfunctions,

e. Hydraulic malfunctions.

f. Single and double engine flameouts.

g. Overheat and engine fire warning procedures.

h. Emergencies leading to ejection.

i. Ejection procedures.

j. Single engine penetration, GCA and go-around.

Figure 7. Sample Simulator Mission Lesson Plan for F-101 Aircraft Transition Training (from ADC Manual 51-101, Volume I).

PHASE II

SIMULATOR MISSION #3

PILOT-RIO RADAR TRAINING

1. Briefing. Emphasis will be placed on:

   a. Scramble and AFIO procedures.

   b. Armament safety checks.

   c. Weapon delivery procedures and escape maneuvers.

   d. Front quarter and cutoff tactics.

   e. Identification attack procedures.

   f. Weapon system emergencies.

2. Procedures. Accomplish the following:

   a. Scramble with AFIO departure.

   b. Primary and secondary 110° and 135° beam attacks both co-altitude and snap-up.

   c. Armament hangfire, misfire and jettison procedures.

   d. Identification passes.

   e. UHF/ADF letdown.

   f. ILS full stop landing.

Figure 8. Sample Simulator Mission Lesson Plan for F-101 Aircraft Qualification Training (from ADC Manual 51-101, Volume I).

PHASE III

SIMULATOR MISSION #3

INSTRUMENT STRANGE FIELD, AND EMERGENCY

1. Purpose. To exercise alternate airfield procedures in event of weather, emergency, or wartime considerations. Assume full armament load.

2. Procedures:

a. AFIO departure from an alternate airfield.

b. Radio out scramble abort.

c. Execute recovery.

d. Execute missed approach (field dropped below minimums).

e. Proceed to briefed alternate (other than home base).

f. En route contact with center on guard using data link and SIF. Clearance received for published (ACIC) approach.

g. Execute holding, TACAN/ILS full stop.

h. Utility hydraulic failure during approach.

i. Barrier engagement.

Figure 9. Sample Simulator Mission Lesson Plan for F-101 Aircraft Continuation Training (from ADC Manual 51-101, Volume I).

Lesson 7

RADAR INTERCEPT-PROFILE
(Aircraft Commander and Pilot)

1. General. This lesson is intended to increase the aircrew's intercept proficiency in the F-4.

2. References. TO 1F-F4C/D-1.

3. Procedures:

a. Practice scramble with instrument departure and climb out to optimum cruise altitude.

b. Optimum cruise to attack vector.

c. Simulated primary attack with secondary reattack.

d. Simulated identification intercept.

e. ECM procedures.

f. Recovery under instrument conditions.

g. Engine shutdown.

4. Critique:

a. Critique each individual intercept before progress to the next intercept.

b. Include in the final critique all errors or omissions noted during the mission.

Figure 10. Sample Simulator Mission Lesson Plan for F-4 Aircrew Qualification Training (from AFM 51-34).

KC-135 FLIGHT SIMULATOR SECTION - STUDENT STUDY GUIDE

Emergencies That Will Be Simulated During Course of Instruction in Simulator

C = CRITIQUE D = DEMONSTRATED X = PERFORM

	EMERGENCY	MISSIONS							
		1	2	3	4	5	6	7	8
1.	Revisions--Ops Procedures, Safety of Flight Supplements	C	C	C	C	C	C	C	X
2.	Checklist use and response	D	X	X	X	X	X	X	X
3.	Crew duties and coordination	D	X	X	X	X	X	X	X
4.	Wrong ground crew response		X	X					
5.	Reversed control movement		X	X					
6.	Position reporting and fuel logs			X	X	X	X	X	X
7.	Fuel management	D	D	D	X	X	X	X	X
8.	Fuel leaks and low fuel pressure			D	X				
9.	Fuel valve failure							X	X
10.	Fuel boost pump failure				X				
11.	Fuel dumping & air refueling pump failure	D				X	X		
12.	Fuel, hydraulic, oxygen quantity failure			X	X			X	
13.	Flight instrument failure			X	X				
14.	Engine instrument malfunctions			X	X				
15.	TACAN, OMNI, ILS failures			X					
16.	Hydraulic system failures		D	X	X		X	X	X
17.	Landing gear or position indicator failure			X					X
18.	Emergency flap operations				X		X		X
19.	Brake operation							X	
20.	Differential spoilers		X						
21.	Generator failures			X	X		X	X	X
22.	Manual paralleling of a.c. generators				X				
23.	TR unit and/or bus failure		D	X			X		
24.	Emergency start - battery power				X				
25.	Stabilizer trim malfunctions		DX		X			X	
26.	Cabin pressurization							X	
27.	Smoke and fumes eliminatio			X	X				X
28.	Oil system malfunctions		X						
29.	Steep turns and unusual attitudes		X			X			X
30.	Turbulence and thunderstorm						D	X	
31.	Pitot and engine icing						D	X	X
32.	Crash landing	C		X					X
33.	Ditching	C							
34.	Bailout	C					X		
35.	Abandon aircraft							X	X
36.	Stalls	D	D						
37.	Aborted takeoff			X			X	X	
38.	Engine fire detector malfunction		X						
39.	Engine overspeed							X	
40.	Engine fire during start or shutdown						X	X	X
41.	Engine fire or failure on takeoff			X	X		X		X
42.	Engine failure during climb and cruise				X			X	
43.	Engine fire during flight		D	X			X		X
44.	Engine airstart and relight		D		X			X	X
45.	Fuselage				X				X
46.	2- and 3-Engine go around		D		X		X		
47.	Emergency breakaway						X	X	
48.	Takeoff & landing with less than full flaps		D		D				

Figure 11. Sample of Student Simulator Study Guide used in KC-135 Simulator Program.

C-130 SIMULATOR RECORD OF PROGRESS *(Continued)*		
LESSON 9	DATE	
OVERALL PROGRESS	**AREAS NEEDING STUDY**	**AREAS NEEDING PRACTICE**
ABOVE AVERAGE ☐	SYSTEMS ☐	PREFLIGHT, START AND RUNUP ☐
NORMAL ☐	LIMITATIONS ☐	SYSTEMS CHECK ☐
BELOW AVERAGE ☐	PROCEDURES ☐	INSTRUMENTS ☐
UNSATISFACTORY ☐		
OTHER REMARKS:		
LESSON 10		
OVERALL PROGRESS	SATISFACTORY ☐	UNSATISFACTORY ☐
AREA RECOMMENDED FOR EMPHASIS DURING FLYING PHASE:		
START, RUNUP ☐	ELECTRICAL SYSTEM ☐	
NORMAL PROCEDURES ☐	PNEUMATIC SYSTEM ☐	
EMERGENCY PROCEDURES ☐	ANTI-ICING AND DE-ICING ☐	
LIMITATIONS ☐	HYDRAULIC SYSTEM ☐	
INSTRUMENTS ☐	ENGINES, FUEL AND OIL ☐	
	PROPELLER SYSTEM ☐	
REMARKS:		

Figure 12. Portion of C-130 Flight Simulator Record of Progress

FLIGHT PROGRESS AND PROFICIENCY RECORD

PROFICIENCY RATING SCALE FOR TTU TRAINING

V. Verbal
D. Demonstration Only.
1. Performed task but needed both physical and verbal assistance from the instructor on more than half the items or trials.
2. Performed the task but needed verbal assistance on less than half of the items or trials.
3. Performed the task but was slow, unsure, made mistakes. Instructor needed to remind student to correct his mistakes.
4. Performed the task, making a few minor errors which were corrected without prompting.
5. Performed the task without error but still needs more practice.
6. Performed the task quickly and without error.

PROFICIENCY RATING SCALE FOR UNIT TRAINING

S – Satisfactory   V – Verbal
T – More Training   D – Demonstration Only

NAME AND GRADE		SERVICE NUMBER	DATE ASSIGNED
AIRCREW POSITION	DATE GRADUATED FROM TTU	TYPE AIRCRAFT	SIMULATOR

AIRCRAFT							TTL TIME THIS AIRCRAFT BROUGHT FORWARD	TOTAL SIMULATOR TIMES THIS AIRCRAFT BROUGHT FORWARD			
FLIGHT NR	DATE (S)	PILOT OR NAV DAY	PILOT OR NAV NIGHT	INST	CO-PILOT	TOTAL TIME THIS FLIGHT	ACCUM AIRCRAFT TOTAL	DATE	PILOT OR FLT ENG	CO-PILOT	ACCUM SIM TOTAL

MATS FORM DEC 64 21

Figure 13. Sample MAC Form 21

FLIGHT NUMBER	INSTRUCTOR	☐ AIRCRAFT ☐ SIMULATOR
REMARKS		
FLIGHT NUMBER	INSTRUCTOR	☐ AIRCRAFT ☐ SIMULATOR
REMARKS		
FLIGHT NUMBER	INSTRUCTOR	☐ AIRCRAFT ☐ SIMULATOR
REMARKS		
FLIGHT NUMBER	INSTRUCTOR	☐ AIRCRAFT ☐ SIMULATOR
REMARKS		
FLIGHT NUMBER	INSTRUCTOR	☐ AIRCRAFT ☐ SIMULATOR
REMARKS		
FLIGHT NUMBER	INSTRUCTOR	☐ AIRCRAFT ☐ SIMULATOR
REMARKS		

Figure 13 (con't). Sample MAC Form 21 (Reverse Side)

PILOT FLIGHT PROGRESS AND PROFICIENCY RECORD

FLIGHT NUMBER																														
I. GROUND OPERATIONS	N	G	N	G	N	G	N	G	N	G	N	G	N	G	N	G	N	G	N	G	N	G	N	G	N	G	N	G	N	G
1. PREFLIGHT (*TOLD, Forms, etc.*)																														
2. STARTING																														
3. TAXI PROCEDURES & TECHNIQUES																														
4. PRE-TAKEOFF PROCEDURES																														
5. ENGINE SHUTDOWN/POST FLIGHT																														
6.																														
7.																														
8.																														
9.																														
II. TAKEOFF AND CLIMB																														
10. NORMAL																														
11. PARTIAL FLAP																														
12. CROSSWIND																														
13. REJECTED TAKEOFF																														
14. ENGINE OUT																														
15.																														
16.																														
17.																														
18.																														
III. LANDINGS AND GO AROUND																														
19. TRAFFIC PATTERN																														
20. NORMAL																														
21. CROSSWIND																														
22. PARTIAL FLAP																														
23. NO FLAP																														
24. BOOST OUT (*Aileron, Rudder, Elev*)																														
25. ENGINE (S) OUT																														
26. TOUCH AND GO																														
27. REVERSING																														
28. NIGHT																														
29. NORMAL GO AROUND																														
30. ENGINE(S) OUT GO AROUND																														
31. FLAMEOUT PATTERN & LANDING																														
32.																														
33.																														
34.																														
35.																														
36.																														
IV. AIRWORK																														
37. CLIMB AND CRUISE																														
38. STEEP TURNS																														
39. SLOW FLIGHT																														
40. APPROACH TO STALL																														
41. BACKSIDE OF POWER CURVE																														
42. HIGH SPEED BUFFET AND TUCK																														
43. DUTCH ROLL & RECOVERY																														
44. UNUSUAL ATTITUDES																														
45. DESCENT																														
46. CHANDELLE																														
47. LAZY EIGHT																														
48.																														
49.																														

MATS FORM DEC 64 21a

LEGEND: N = Number G = Grade

Figure 14. Sample MAC Form 21a

FLIGHT NUMBER																														
V. INSTRUMENT PROCEDURES	N	G	N	G	N	G	N	G	N	G	N	G	N	G	N	G	N	G	N	G	N	G	N	G	N	G	N	G	N	G
50. SID																														
51. HOLDING																														
52. PENETRATION																														
53. GCA																														
54. ILS																														
55. VOR																														
56. TACAN																														
57. ADF																														
58. CIRCLING																														
59. MISSED APPROACH																														
60. ORIENTATION																														
61.																														
62.																														
VI. EMERGENCY PROCEDURES																														
63. BAILOUT																														
64. DITCHING																														
65. CRASH LANDING																														
66. GEAR MALFUNCTION																														
67. PRESS/AIR COND/HEATERS																														
68. EMERGENCY DESCENT																														
69. SMOKE AND FUME ELIMINATION																														
70. ANTI-ICE AND DE-ICE																														
71. ENGINE FIRE/FAILURE/OVERHEAT																														
72. AIR START/RE-START																														
73. APU/APP FIRE/OVERHEAT																														
74. ELECTRICAL FIRE/FAILURE																														
75. INVERTER/T/R FAILURE																														
76. FUSELAGE FIRE																														
77. WING FIRE																														
78. CADC FAILURE																														
79. INSTRUMENT FAILURE																														
80. FLIGHT CONTROL FAILURE																														
81. HYDRAULIC FAILURE																														
82. OIL SYSTEM																														
83. FUEL SYSTEM																														
84. EMERGENCY BRAKES																														
85.																														
86.																														
87.																														
88.																														
89.																														
90.																														
VII. GENERAL *(Use S or U)*																														
91. ATTITUDE																														
92. JUDGMENT																														
93. CREW COORDINATION																														
94. INTERPHONE/RADIO PROCEDURES																														
95. USE OF CHECK LISTS																														
96. USE OF NAVIGATION RADIOS																														
97. CO-PILOTS DUTIES																														
98.																														
99.																														
100.																														
101.																														

865-3075

Figure 14 (con't). Sample MAC Form 21a (Reverse Side)

INSTRUMENT GRADE SLIP
UNDERGRADUATE PILOT TRAINING (T-37)

Reflect the student's characteristic performance on this flight by circling (◯) appropriate spaces below.
U – UNABLE TO ACCOMPLISH F – FAIR G – GOOD E – EXCELLENT

1. GROUND OPERATIONS	U	F	G	E	12
VISUAL INSPECTION	0	1	2	3	
COCKPIT CHECK	0	1	2	3	
ATC CLEARANCE	0	2	4	6	
2. INSTRUMENT TAKEOFF	U	F	G	E	21
DIRECTIONAL CONTROL	0	3	6	9	
TAKEOFF ATTITUDE	0	2	4	6	
PROCEDURES	0	2	4	6	
3. CLIMBS	U	F	G	E	18
CLIMB ENTRY	0	2	4	6	
BANK CONTROL	0	2	4	6	
T. O. CLIMB SPEED	0	2	4	6	
4. LEVEL OFF	U	F	G	E	12
HEADING CONTROL	0	1	2	3	
ALTITUDE CONTROL	0	1	2	3	
AIRSPEED CONTROL	0	1	2	3	
PROCEDURES	0	1	2	3	
5. STRAIGHT & LEVEL	U	F	G	E	18
HEADING CONTROL	0	2	4	6	
ALTITUDE CONTROL	0	2	4	6	
AIRSPEED CONTROL	0	2	4	6	
6. TURNS – TURNS TO HDGS	U	F	G	E	18
BANK CONTROL	0	2	4	6	
ALTITUDE CONTROL	0	2	4	6	
AIRSPEED CONTROL	0	2	4	6	
7. CLIMBS & DESCENTS	U	F	G	E	18
AIRSPEED CONTROL	0	2	4	6	
DIRECTIONAL CONTROL	0	2	4	6	
VV OR POWER CONTROL	0	2	4	6	
8. CHANGE OF A/S	U	F	G	E	15
POWER CONTROL	0	2	4	6	
ALTITUDE CONTROL	0	2	4	6	
BANK OR HDG CONTROL	0	1	2	3	
9. VERTICAL "S" A-B-C-D	U	F	G	E	18
VV CONTROL	0	2	4	6	
AIRSPEED CONTROL	0	2	4	6	
BANK OR HDG CONTROL	0	2	4	6	
10. RATE & TIMES TURNS	U	F	G	E	15
CALIB OF TURN NEEDLE	0	1	2	3	
BANK CONTROL	0	1	2	3	
ALTITUDE CONTROL	0	1	2	3	
AIRSPEED CONTROL	0	1	2	3	
TIMING	0	1	2	3	

11. MAGNETIC COMPASS	U	F	G	E	12
BANK CONTROL	0	1	2	3	
ALTITUDE CONTROL	0	1	2	3	
AIRSPEED CONTROL	0	1	2	3	
ROLLOUT HEADING	0	1	2	3	
12. STEEP TURNS	U	F	G	E	18
BANK CONTROL	0	2	4	6	
ALTITUDE CONTROL	0	2	4	6	
AIRSPEED CONTROL	0	2	4	6	
13. CONFIDENCE MANEUVERS	U	F	G	E	18
AILERON ROLL	0	2	4	6	
WINGOVER	0	2	4	6	
LOOP	0	2	4	6	
14. UNUSUAL ATTITUDES	U	F	G	E	18
ATTITUDE RECOGNITION	0	3	6	9	
RECOVERY	0	3	6	9	
15. RADAR APPROACH	U	F	G	E	39
PROCEDURES	0	2	4	6	
BASIC INSTRUMENTS	0	2	4	6	
GLIDE PATH	0	3	6	9	
AZIMUTH	0	3	6	9	
MISSED APPROACH	0	2	4	6	
VOICE PROCEDURES	0	1	2	3	
16. BASIC VOR	U	F	G	E	48
TUNING & IDENT.	0	2	4	6	
HOMING	0	1	2	3	
COURSE INTERCEPTION	0	2	4	6	
MAINTAINING COURSE	0	2	4	6	
TIME & DIST. CHECK	0	1	2	3	
PROCEDURE TURNS	0	2	4	6	
STATION PASSAGE	0	1	2	3	
DEPARTURE	0	2	4	6	
BASIC INSTRUMENTS	0	2	4	6	
VOICE PROCEDURES	0	1	2	3	
17. VOR HOLDING	U	F	G	E	24
ENTRY	0	2	4	6	
TIMING	0	2	4	6	
DRIFT CORRECTION	0	2	4	6	
BASIC INSTRUMENTS	0	2	4	6	
18. VOR PENETRATION	U	F	G	E	21
ENTRY	0	1	2	3	
AIRSPEED CONTROL	0	1	2	3	
BANK CONTROL	0	2	4	6	
LEVEL OFF	0	1	2	3	
MAINTAINING COURSE	0	2	4	6	

STUDENT'S LAST NAME – FIRST NAME – MIDDLE INITIAL		RANK	CLASS & FLT DSG		INITIALS BY STU	
MISSION OR LESSON DESIGNATION	DATE OF FLIGHT	FLIGHT TIME	OVERALL EVALUATION			
			UNSAT	FAIR	GOOD	EXCEL
INSTRUCTOR OR CHECK PILOT SIGNATURE	RANK	TITLE	PTS REC	PTS POS	RAWSCORE	ST SCORE

ATC FORM APR 66 267 PREVIOUS EDITIONS OBSOLETE. AFPS SA

Figure 15. T-37 Instrument Grade Slip

19. VOR LOW APPROACH	U	F	G	E	33
CONFIGURATION	0	1	2	3	
MAINTAINING COURSE	0	2	4	6	
AIRSPEED CONTROL	0	2	4	6	
ALTITUDE CONTROL	0	2	4	6	
TIMING	0	2	4	6	
MISSED APPROACH	0	2	4	6	

20. GENERAL AIRMANSHIP	U	F	G	E	30
INSTRUMENT CROSSCHECK	0	2	4	6	
INSTRUMENT INTERPRETATION	0	2	4	6	
USE OF TRIM	0	2	4	6	
AIRCRAFT CONTROL	0	2	4	6	
INFLIGHT CHECKS	0	2	4	6	

21. EMERGENCY PROCEDURES	U	F	G	E

22. VFR PATTERN & LANDING	U	F	G	E

REMARKS

Figure 15 (con't). T-37 Instrument Grade Slip (Reverse Side)

GRADING CRITERIA FOR GENERAL MANEUVERS

		EXC	GOOD	FAIR	
A.	ITO, Climbs, Descents (Rate & Constant) Penetration, Level Off.	2	4	5	HDG MAX
		2	5	8	KTS MAX
		50	75	100	ALT MAX
B.	Cruising, Change of A/S, Change of A/S in Turns.	2	4	5	HDG MAX
		2	3	5	KTS MAX
		50	75	100	ALT MAX
C.	Turns & Turns to Headings.	0	2	4	DEG BANK MAX
		2	4	5	HDG MAX
		2	3	5	KTS MAX
		50	75	100	ALT MAX
D.	Steep Turns	2	3	5	DEG BANK MAX
		3	5	7	HDG MAX
		3	5	7	KTS MAX
		75	100	150	ALT MAX
E.	Vertical S's	0	2	4	DEG BANK MAX
		2	4	6	KTS MAX
		20	40	60	ALT MAX
		100	150	200	V.V. MAX
F.	Low Altitude Patterns	1	3	5	HDG MAX
		0	2	5	DEG BANK MAX
		2	3	5	KTS MAX
		50	75	100	ALT MAX
		4	6	10	SEC IN TIME
		2	4	5	DEG TRACK ERR.

Figure 16. Sample of Grading Criteria Employed for Synthetic Instrument Training in ATC.

STATUS AND USE REPORT OF SELECTED TRAINING DEVICES	ORGANIZATION 443 Mil Alft Wg (Tng)			COMMAND OF ASSIGNMENT MAC	REPORTS CONTROL SYMBOL AF-E7
	LOCATION Tinker Air Force Base, Oklahoma				AS OF DATE 30 September 1966
TYPE DESIGNATION AND SERIAL NUMBER A	STATUS CODE B	TRAINING HOURS OPERATED C	REMARKS D		
***A/F 37A-T24A (C-141A) 325-3	A	398	***TCTO 43D3-3-14-556, Incorporation of Misc Aircraft Changes, completed 9 Sep 66. ***TCTO 43D3-3-14-558, Incorporation of Misc Aircraft Changes, completed 24 Sep 66.		
****SMK-43/37A-5 (C-141A) Visulator AF 62-9	B	0	****Unit inoperative due to 25 KV power supply failure. NOTE: All Down Time re-scheduled and made up during Sept 1966 71 hours underfly due to approved reduction in hours per MAC (MAOTNO) Ltr, 27 Jul 66, Proposed Training Program Changes. This time will not be made up.		

Figure 17. Sample E7 Report Submission

CODE	CMD	STATION	A DESIGNATOR	SN	STATUS	B HOURS
G	ADC	TEXARKANA	AN/GPS-T4	00033	A	
G	ADC	TEXARKANA	AN/GPS-T4	00033	A	
G	ADC	TEXARKANA	AN/GPS-T4	00033	A	
G	ADC	TEXARKANA	AN/GPS-T4	00033	A	
A	ADC	TRAVIS	MB-5C	56-00002	A	138
A	ADC	TRAVIS	MB-5C	56-00002	A	79
A	ADC	TRUAX	MB-5C	55-00003	A	54
A	ADC	TRUAX	MB-5C	55-00003	A	58
A	ADC	TRUAX	MB-5C	55-00003	A	55
A	ADC	TRUAX	MB-5C	55-00003	A	53
A	ADC	TRUAX	MB-5C	55-00003	A	
A	ADC	TRUAX	MB-5C	55-00003	A	16
						453
A	ADC	TYNDALL	MB-40	56-00007	B	15
A	ADC	TYNDALL	MB-40	57-00013	A	68
A	ADC	TYNDALL	MB-40	56-00007	A	123
A	ADC	TYNDALL	MB-40	57-00013	A	102
A	ADC	TYNDALL	MB-40	56-00007	A	85
A	ADC	TYNDALL	MB-40	57-00013	A	81
A	ADC	TYNDALL	MB-40	56-00007	A	78
A	ADC	TYNDALL	MB-40	57-00013	A	85
A	ADC	TYNDALL	MB-40	56-00007	A	81
A	ADC	TYNDALL	MB-40	57-00013	A	56
A	ADC	TYNDALL	MB-40	56-00007	A	129
A	ADC	TYNDALL	MB-40	57-00013	B	26
						929
A	ADC	TYNDALL	MB-42	57-00003	A	92
A	ADC	TYNDALL	MB-42	59-00007	A	67
A	ADC	TYNDALL	MB-42	57-00003	A	100
A	ADC	TYNDALL	MB-42	59-00007	A	130
A	ADC	TYNDALL	MB-42	57-00003	A	113
A	ADC	TYNDALL	MB-42	59-00007	A	103
A	ADC	TYNDALL	MB-42	57-00003	A	125
A	ADC	TYNDALL	MB-42	59-00007	A	126
A	ADC	TYNDALL	MB-42	57-00003	A	72
A	ADC	TYNDALL	MB-42	59-00007	A	99
A	ADC	TYNDALL	MB-42	57-00003	A	63
A	ADC	TYNDALL	MB-42	59-00007	A	80
						1170

Figure 18. Sample page of Consolidated AF-E7 Utilization Report

TRAINER UTILIZATION REPORT

ORGANIZATION: 4457 CCr Tng Sq
COMMAND OF ASSIGNMENT: TAC
REPORTS CONTROL SYMBOL: AF - E7 (TAC-1)
LOCATION: Davis-Monthan AFB, Arizona 85707
AS OF DATE: 31 August 1966

TYPE DESIGNATION	HOURS							REMARKS (CONTINUE ON REVERSE)
	QUARTER				MONTH			
	RE-QUIRED	PRO-GRAMMED TO DATE	COM-PLETED TO DATE	AVAIL-ABLE TO DATE	SCHED-ULED	STUDENT NO SHOW	LOST FOR OTHER REASONS	
A	B	C	D	E	F	G	H	I
AF/37U-T1 (F4C) AF-4, AF-5, AF-7, AF-8, AF-11.	3342	2180	1968	2423	1059	0	112	Col E - 343 hrs of available time lost due to building air conditioning inop. Col H - 18 hrs lost facilities power failure. 34 hrs lost AMP. 28 hrs lost building central air conditioner. 32 hrs lost due to unscheduled maintenance.
AF/37U-T3 (F4D) AF-1	480	265	255	595	230	0	9	Col H - 2 hours lost facilities power failure. 7 hours lost due to unscheduled maintenance.
AF-37A-T18 (AGM-12) 62-22	205	142	142	890	110	0	0	3270 completed launches. Col E - 49 hours of available time lost due to building air conditioning installation. NOTE 1 - 1575 hours spent performing maintenance. NOTE 2 - 6068 maintenance man-hours.

Figure 19. Sample TAC Form 44 Utilization Report

SYNTHETIC TRAINING DEVICES OPERATIONAL STATUS AND EVALUATION REPORT										AS OF DATE (LAST DAY OF CALENDAR MO.) 31 Aug 66	REPORTS CONTROL SYMBOL SAC - E2
TO: (MAJ SUB COMD HQ) 15AF (DOOTTG)				INFO TO: Hq SAC (DOTAG)						FROM: (ORGN, COMD OF ASSIGNMENT & LOCATION) 93 Bombardment Wing, (SAC) Castle AFB, California	
TYPE & SERIAL NO. (INCL MAJ ATCH OF DEVICES BEING REPORTED)	STATUS	POWER ON HOURS	CUMU-LATIVE POWER ON	TRAINER HOURS SCHED	TRAINER HOURS UTILIZED	% SCHED TRAINING COMPL	TRAINING HOURS LOST			REMARKS	
							MAINT	NO SHOW	OTHER		
A	B	C	D	E	F	G	H	I	J	K	
S-9 (B-52B) #53-101	A	427	61309	96	87	91%	0	9	0		
MB-41 (B-52D) #56-104 e/w ACR	A	534	53336	213	195	92%	0	18	0		
AN/F37A-T1 (B-52G) #57-109 e/w ACR	A	546	40112	165	150	91%	0	15	0	T. C. T. O. 43D3-2-5-665 Completed 19 Aug 66.	
MB-41A (B-52F) #59-117 e/w ACR	A	531	34164	214	199	93%	0	15	0		
MB-41 (B-52D) #56-106 (Mobile) e/w ACR	A	484	36814	196	169	86%	0	0	27	BAR-NONE Exercise	
MB-41 (B-52D) #55-102 (Mobile) e/w ACR	A	406	62194	165	159	96%	0	0	6	High Winds	
AN/F37A-T25 (B-52H) #59-114 (Mobile) e/w ACR	A	506	30600	246	246	100%	0	0	0		
AN/F37A-T25 (B-52H) #59-113 (Mobile) e/w ACR	A	575	30178	324	318	98%	6	0	0	Air Conditioning	

Figure 20. Sample SAC E2 Utilization Report

STANDARDIZATION EVALUATION-INSTRUMENTS		FLIGHT	GROUND	DATE		
		TYPE CHECK:				
LAST NAME-FIRST-MIDDLE INITIAL	GRADE	WRITTEN:				
		ERRORS:				
				PTS. REC.	PTS. POS	SCORE
ORGANIZATION	DUTY TITLE	INSTR. TECH.	Q U			
		FLY PROF:	Q U			
		OVERALL:	Q U			

ITEM	INSTRUCTION TECHNIQUE U	M	S	E	ERRORS	FLYING PROFICIENCY U	M	S	E	REMARKS
1. VISUAL INSPECTION	0	1	2	3		0	1	2	3	
2. TAXI	0	1	2	3		0	1	2	3	
3. INSTRUMENT TAKEOFF	0	3	6	9		0	3	6	9	
4. INSTRUMENT DEPARTURE	0	3	6	9		0	3	6	9	
5. TURN INDICATOR CALIB.	0	1	2	3		0	1	2	3	
6. LEVEL OFF	0	2	4	6		0	2	4	6	
7. PITCH CONTROL	0	4	8	12		0	4	8	12	
8. BANK CONTROL	0	4	8	12		0	4	8	12	
9. POWER CONTROL	0	4	8	12		0	4	8	12	
10. TRIM	0	3	6	9		0	3	6	9	
11. CLIMBS & DESCENTS	0	3	6	9		0	3	6	9	
12. VERTICAL 'S'	0	3	6	9		0	3	6	9	
13. STEEP TURNS	0	3	6	9		0	3	6	9	
14. AIRSPEED CHANGE	0	2	4	6		0	2	4	6	
15. RATE & TIMED TURNS	0	2	4	6		0	2	4	6	
16. UNUSUAL ATTITUDES	0	3	6	9		0	3	6	9	
17. CONFIDENCE MANEUVERS	0	3	6	9		0	3	6	9	
18. ADF	0	4	8	12		0	4	8	12	
19. VOR	0	5	10	15		0	5	10	15	
20. TACAN	0	5	10	15		0	5	10	15	
21. HOLDING	0	3	6	9		0	3	6	9	
22. PROCEDURE TURNS	0	3	6	9		0	3	6	9	
23. PENETRATION	0	3	6	9		0	3	6	9	
24. LOW APPROACH	0	4	8	12		0	4	8	12	
25. MISSED APPROACH	0	3	6	9		0	3	6	9	
26. RADAR APPROACH	0	5	10	15		0	5	10	15	
27. ILS	0	5	10	15		0	5	10	15	
28. CLEARING						0	5	10	15	
29. RADIO PROCEDURES	0	2	4	6		0	2	4	6	
30. GROUND CHECKS	0	1	2	3		0	1	2	3	
31. FLIGHT CHECKS	0	1	2	3		0	1	2	3	
32. FLIGHT PLANNING						0	4	8	12	
33.										
34. 267										294

GROUND BRIEFING	U	M	S	E

ERRORS	ITEM

ATC FORM MAR 66 610C PREVIOUS EDITIONS OBSOLETE AFPS SA

Figure 21. Sample ATC Form 610C

FLIGHT EXAMINER COMMENTS	
SIGNATURE OF EXAMINEE	SIGNATURE OF FLIGHT EXAMINER
SIGNATURE OF SUPERVISOR	

Figure 21 (con't). Sample ATC Form 610C (Reverse Side)

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This report describes flight simulator utilization and training practices within the U.S. Air Force. Data are presented concerning simulator training objectives, curricula, instructional methods, personnel, and support factors which affect utilization and program effectiveness. Information relating to the acceptance of flight simulators by pilot training personnel is included. In addition, recommendations and research issues are presented for improving the effective utilization of existing flight simulators and for the development of future simulator training requirements and programs.

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